Research Product 86-24

Guidelines for Automation: A How-To Manual for Units Receiving Automated Command and Control Systems

ARI Field Unit at Fort Leavenworth, Kansas

Systems Research Laboratory

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FOREWORD

The Army Research Institute for the Behavioral and Social Sciences (ARI) maximizes combat effectiveness through research in the acquisition, development, training, and utilization of soldiers in military systems. The ARI Field Unit at Fort Leavenworth supports the Combined Arms Center by developing research products designed to increase the combat effectiveness of command groups and command staff operations by improving command and control performance capabilities. Of special interest is research in the use of automation to improve command and control operations.

The Combined Arms Center is responsible for integrating efforts to develop automated command and control systems, to include informal efforts, characterized as field unit initiatives. Such field unit initiatives have made a significant contribution to the initial development of the tactical portions of the Army Command and Control System (ACCS). As the ACCS systems are fielded, the need for user initiative continues, both to determine the optimal use of the systems and to aid in their evolutionary development. This manual provides guidance to assist field unit users in these tasks. The guidelines presented were designed to assist field users in smoothing the transition to new systems by providing insights into the problem of building man-machine systems that take full advantage of <u>all</u> system components, and by providing tools to be used to accomplish the necessary system integration.

The application of principles set forth in this document will assist users to achieve more quickly the improved command and control performance standards inherent in Future Battle Doctrine.

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The manual provides information to field unit users who are responsible for introducing automation into command and control functions. Army efforts to automate the command and control system are described, and the role of the field units in the effort is outlined. Guidelines are provided to assist field units in developing garrison and tactical applications. Included are guidelines for assembling the personnel, organizing the effort, identifying candidate applications, refining and developing the concept, (Continued)

ARI Research Product 86-24

20. (Continued)

constructing flow charts of the process, defining the requirements, and conducting the demonstration and trials. Not included are the technical areas of programming and software design.

Research Product 86-24

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This manual is based largely on the interim research product, Guidelines for Automating Command and Control Functions in Field Units (ARI Research Product 84-07) by Steven R. Stewart (U.S. Army Research Institute), and Glen Ross and Roland V. Tiede (Science Applications, Inc.).

Additionally, the efforts of COL J. Granrud, CPT G. C. Harris, and Mr. John Stucker, all of the C^3I Directorate of the Combined Arms Combat Developments Activity are acknowledged.

GUIDELINES FOR AUTOMATION: A HOW-TO MANUAL FOR UNITS RECEIVING AUTOMATED COMMAND AND CONTROL SYSTEMS

CONTENTS

CHAPTER 1: INTRODUCTION

Command and control of US Army units has historically been performed in a manual mode. Command and control has included voice and message traffic for the passage of information, and manual correlation of information in command posts, corps through brigade. There is more information about the battlefield available today than ever before, yet the staff processes information essentially as it always has. While the existing command and control system contains some time saving automated procedures, it primarily remains a system of manual procedures. The system involves repetitive manual entering, transcribing, and posting of data, increasing the chances for error, especially in a stressful combat situation. This system has evolved in an environment far less dynamic than that expected to exist in future combat. The present system has serious deficiencies in responsiveness, survivability, and dependability that would preclude timely decision making by commanders and staffs, affecting battle results adversely.

The forces of the Warsaw Pact represent the most formidable threat to the US Army in the forseeable future. Warsaw Pact forces have long enjoyed the advantages of numerical superiority over the forces of NATO. The margin of this superiority is increasing and will continue to increase into the next decade. The United States has maintained a sizable technological advantage over its potential adversaries, and it is likely that advantage will increase. Recent advances in data processing technology have been enormous and, without question, future developments will bring computers which are even more powerful, reliable, compact, and economical. The challenge which faces the US Army is to employ that technological advantage through the development of the automated command and control systems which will allow the commander to fight the battle in depth, with synchronization and agility, and to exercise the quality and responsive command and control necessary to fight outnumbered and win.

-- is clear that the employment of automation will play an increasing role in providing the means of control and in supporting the execution of command in the Airland Battle. The Army is investing heavily to develop and procure the appropriste systems. Army Regulation 11-39 established the Army Command and Control System (ACCS) and prescribes policy, guidance and responsibility for managing the evolutionary development of the Army's entire command and control system. The responsibilities of the ACCS Architect are assigned to the Commander of the US Army Training and Doctrine Command (TRADOC) and the responsibilities of ACCS System Engineer are assigned to the Commander of the Army Material Command (AMC). The US Army Combined Arms Center (CAC) is responsible for the coordination of the Army Command and Control System and is the TRADOC proponent for command, control, communication, and intelligence combat developments. The tactical portion of ACCS has been designated as the Army's Command, Control, and Subordinate Systems (CCS^2). The next chapter of this book includes a discussion of Command, Control, and Subordinate Systems.

The field units will not, however, simply wait for the fielding of the objective systems of the ACCS. Field unit officers are the experts in tactical operations, understand their current procedures completely, and will be the ultimate users of the system. Their contributions during its development will be vital to the success of the entire program. Further, once the command, control, and subordinate systems are fielded, they will follow an evolutionary development, the success of which depends heavily on field unit user initiative. On the other hand, the field units should not attempt to build tactical systems independently. The availability of relatively inexpensive microcomputers in the commercial market has led to a proliferation of such attempts. Many of these unit initiative systems had non-interoperable hardware and software and designs which were inconsistent with the emerging ACCS architecture. This tends to greatly restrict the value of such independent developments to the Army as a whole and detracts from the development and fielding of the objective command and control systems. With the notable exception of DCCS (Distributed Command and Control System) developed at Fort Lewis and discussed in Chapter 2 of this manual, unit attempts to apply automation to tactical operations have had little lasting value. Additionally, because they do not take advantage of the work which has already been accomplished, independent initiatives usually involve a significant duplication of effort. Unit automation initiative is strongly encouraged because of its potential value, however, it is essential that the effort be coordinated through the responsible Army agency. When the object of automation is the tactical command and control system, the responsible agency is the Command, Control, Communications, and Intelligence Directorate (C^3I) of the Combined Arms Combat Developments Activity (CACDA) at Fort Leavenworth.

As the CCS^2 control systems are fielded, the field units will play an important role in the Army automation effort. There are four areas of activity which comprise that field unit role.

1. Developing Garrison Applications. The unit may develop applications, using CCS^2 equipment, to assist garrison operations. Although the systems have been designed for tactical operation and their configuration and use in the TOC have been established, the individual units are left to solve the problem of how to reconfigure and use the equipment in their unique garrison applications. Software useful for this purpose is provided with all the CCS^2 control systems. This software includes an operating system, data-base management, communication processing, user tools, (e.g., Lotus and Wordstar), and a graphics package. The importance of field unit initiative in developing garrison applications goes well beyond the value such applications would have for aiding garrison operations; the familiarity with the equipment gained in garrison will be significant when the equipment is put to tactical use. If the computers just go in the closet when the unit returns from the field, the "training-retraining" and "computer anxiety" problems in the field will be greatly increased.

2. Guiding the Development of CCS^2. The Maneuver Control System (MCS) and the other control systems of CCS^2 will follow an evolutionary method of development. Field units will have the opportunity to submit recommendations for modifications to the system developers and, each year, updated versions of the systems will be delivered to the users. This allows the system to both grow in power and adjust to new or changed tactical requirements. The concept for the unit role in evolutionary development goes beyond the submission of proposals. Units are encouraged to develop tactical applications using the CCS^2 computers or other computers which exist in the unit. Tactical systems will then include

a "formal" component, consisting of the standardized CCS^2 control system delivered to all the units, and an "informal" component developed internally. Elements of the informal component, having been refined and validated by field use, may later be incorporated in future editions of the "formal" component and spread Armywide. As recommended earlier, initiatives in the tactical arena should be coordinated with the C^3I directorate of CACDA at Fort Leavenworth.

3. Restructuring Operating Procedures. The CCS^2 are information processing systems; they will change the speed, the amount, and the organization of the information which flows during tactical operations. The tactical C^2 system is a system of men and machines. The system developers have defined and standardized the operation of the machine component; the operation of the human component must also change. The task which confronts the field units is to change their operating procedures to maximize the benefits of automation. The accomodations to automation in such areas as unit SOP and task assignment will require unit effort and experimentation.

4. Incorporating the work of other units. Other units may have already developed software for a particular military purpose and your unit may wish to adapt it to your organization. For example, both the Air Force and the XVIII ABN CORPS have developed relatively powerful computer programs to assist in aircraft load planning. Although these programs are already developed and operating there are several tasks required before they could be transported to your unit, including the preparation of a concept of operation, requirements definition, and a careful study of the effects on unit SOP, task assignment, etc. Units may keep abreast of developments elsewhere through such publications as C^2MUG, published by the Communications-Electronic Command (CECOM) at Fort Leavenworth and by contacting the C^3I Directorate of CACDA or your Automation Management Office.

This manual provides information for field unit officers who are responsible for managing the introduction of automation into command and control functions. It is designed to assist in the four tasks described above. This document does not address the technical areas of programming and software design. Rather, it addresses issues that must be considered in exploiting capabilities to further improve command and control operations. In addition to basic guidelines for organizing the effort, the manual provides guidance for each of the necessary steps in implementing an effort to apply automation to tactical or garrison operations. These steps are: concept development, requirements definition, system development, and demonstration and trials. Figure 1-1 illustrates the development cycle.

Chapter 2 of this manual is a summary of the Army automation effort and a description of the tactical portion of the ACCS, the Command, Control, and Subordinate Systems. Chapter 3 gives some guidelines for organizing the automation effort. These basic principles were discovered by field unit members in USAREUR and CONUS who were early experimenters with C^2 automation. Chapter 4 shows how to make flow charts of information processing systems. This chapter also provides a basis for estimating the potential benefits of automation. Chapter 5 describes the process of concept development whereby new ideas are transformed into detailed, well-defined and analyzed concepts. Chapter 6

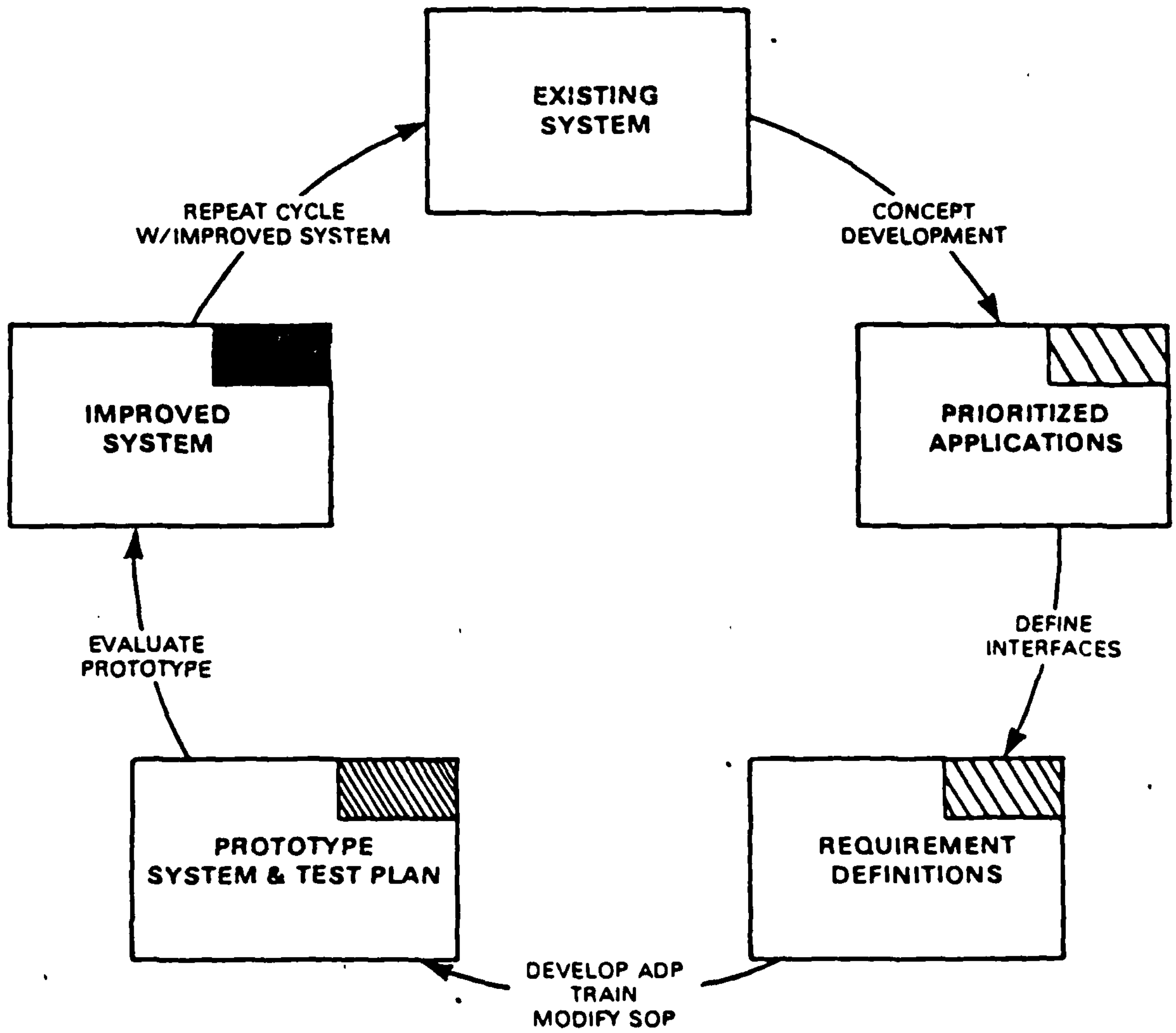

Figure 1-1. DEVELOPMENT CYCLE

explains a method for systematically identifying the information flow requirements, an analysis which is necessary for software design. Chapter 7 presents several useful principles for planning and conducting the demonstration and trials, and for promoting the continued acceptance of automation by the unit. Finally, a reference list is included.

CHAPTER 2: THE ARMY AUTOMATION EFFORT

The pace of battle up until the time of World War II was such that the commander, aided by his principal staff, could gather and process incoming information, carefully develop hypotheses, evaluate the various options available, select what appeared to be the optimal solution and flesh out the plans and orders for implementation. This situation began to change even in WWII. Increased speed of both ground and air movement coupled with improved communications began to tax the commander's ability to accomplish these functions. This in turn resulted in major organizational changes in each of the services in order to achieve the required response capabilities. It was during this time that the concept of the task force and task group and the "fragmentary order" procedure were developed and refined to cope with the greater fluidity of operations.

Since WWII, a great deal of new technology has been absorbed into the force. These capabilities include:

- Increased sensor range and effectiveness.
- Increased weapon range and rates of fire.
- Greatly improved terminal effects, including tactical nuclear weapons.
- Terminal guidance (easing the target location problem).
- Vastly improved capabilities to process information and speed its flow in closing the target-sensor weapon loop (principally in the Field Artillery and Air Defense Artillery weapon systems).
- Satellite Communications capability.
- Increased communication reliability.

These developments, which represent the most significant ones since the end of WWII, are, with the exception of the final two, associated with the object systems or the "effectors" of the force as opposed to the "action initiator" or the command and control process. John H. Cushman, former commanding general of the Combined Arms Center writes:

> Today, except for such modest aids as Microfix, the [G-2] and his helpers display all . . . information manually - - on sheets of paper, on acetate with grease pencils, in an enemy order-of-battle book, and so on. The system has changed hardly at all since 1917-18's American Expeditionary Force in France.

> The wrap leggings of the AEF exist only in museums, but the intelligence processing methods of the AEF still exist in every division command post today.[1]

When we examine the technology which has been developed in recent years to improve the C^2 system we find the following:

- Secure FM voice radio. This made a substantial contribution to reducing time lines.

- Exponential increase in communication channels. The effect of this has been to provide more raw data for processing but has hardly speeded decision making and has certainly added to the electronic signature problem.

- Replacement of tracing paper by acetate. This increased the convenience factor but did nothing to substantially reduce time lines.

These technological "fixes" have not allowed the C^2 system to keep pace with combat force "effector" capabilities and are hardly sufficient to concentrate forces at the right time and place in order to seize the initiative. This fact has even been recognized by the Soviets, whose doctrine calls for a more brute force and mechanistic mode of operations (or one where less reliance has to be placed on the C^2 element). General of the Army S.M. Shtemenko, U.S.S.R. has stated:

> The volume of information that staffs must process has increased many fold since World War II, and the time allowed for decisionmaking has decreased many fold. As a result, the requirements on the "brain capacity" of commanders and staffs have increased vastly. To meet these requirements by simply extending the administrative operation is fundamentally impossible. The only escape from this incompatible situation lies in the extensive application of automation, primarily computers . . . a "man-machine" system is more perfect than "man" alone or "machine" alone . . . Information and technology does not simply help the commander and his staff, but also stimulates the development of collective military creativity, in which the largest group of people, including those separated by great distances, can participate.[2]

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[1] J.H. Cushman (1985). Command and Control of Theater Forces: The Korean Command and Other Cases. Center for Information Policy Research, Harvard University. Cambridge, Massachusetts.

[2] V.V. Druzhinin and D.S. Koutorov (1972). Foreword to the Russian Edition of Concept, Algorithm, Decision (A Soviet Way), by S.M. Shtemenko (General of the Army, U.S.S.R.) Superintendent of Documents, U.S. Government Printing Office, Catalog No. D301.79:6, Stock No. 008-070-00344-9.

2.1. The TOS Program

The first twenty years of the Army automation effort were embodied by the TOS program. From 1958-1964 the system concept was called FIELDATA and was directed at the field army level. It was a display-oriented system that provided for storage and retrieval of selected information. After 1964 the experimental system was known as the European Tactical Operations System (EUROTOS) and was directed at both the field army and corps levels. The concept for the system was expanded during this time but implementation never passed the storage and retrieval stage. From 1970-1973 there was the Developmental Tactical Operations System (DEVTOS). The DEVTOS used EUROTOS hardware and software to evaluate automation at the division level. The Tactical Operations System, Operable Segment (TOS^2) (1971-1977) was also a division level concept but used militarized hardware (the GNY-K12, the central processor for TACFIRE) as opposed to the commercial hardware which had been used in the past. Selected functional areas (operations and intelligence) were implemented, but here again the automated functions went no further than storage and retrieval of unprocessed information. The Division TOS (DTOS) program ran between 1973 and 1979 and was an attempt to identify functional area requirements for automation. Additionally, military hardware development was initiated and alternate system operational configurations were explored down to and including the battalion level. The formal TOS program was discontinued by the Army in 1979 as a result of House and Senate Defense Appropriation Committee actions. Congress correctly perceived that the TOS program was going nowhere after more than 100 million dollars had been spent. The appropriation committee did not delete the research and development funds for the TOS, a signal that the need the program was intended to fill was still viewed as being a valid one. It was on this available thread that the Army began to pull together its efforts in the command and control automation arena. In the late 70's and early 80's senior Army leadership formalized the Army Command and Control System (ACCS) concept.

2.2. The Distributed Command and Control System

Before presenting the details of ACCS and the Command, Control, and Subordinate Systems, two other significant developments which occurred during the first half of the decade will be addressed: the Distributed Command and Control System (DCCS) and the Army Command and Control Initiatives Program (TACIP). DCCS was a field initiative developed at Ft. Lewis, Washington by the Army Development and Employment Agency (ADEA) and tested by the 9th Infantry Division. Based on the 16-bit Intel Grid microcomputers and a videographics subsystem, DCCS provided automation support for command and staff actions and the capability to organize and distribute the results of these actions among the functional elements of the division. Central features of DCCS were force level staff integration capability, data base management with replicated data bases to increase survivability, and a decision graphics package. The evolutionary development of DCCS was discontinued in 1985, with the merger of DCCS and the Maneuver Control System (MCS), one of the Command, Control, and Subordinate Systems.

2.3. The Army Command and Control Initiatives Program

The TACIP program arose from a need to coordinate the activity of the many field units which had, on their own initiative, begun to apply microcomputer technology to command and control problems. As previously mentioned, many of the initiatives had non-interoperable hardware and software, and were inconsistent in design with the ACCS architecture. Additionally, there was no structure to allow sharing of information among field units and there was no formal mechanism which would allow continuity of effort and long term stability of initiatives. The US Army Combined Arms Center recognized the potential contribution of these initiatives and, in September 1982, established the Army Command and Control Initiatives Program. The general goals of TACIP are to firm up the management of the command and control field initiatives and to integrate the bottoms-up approach with the top-down development of the ACCS implementation plan, the Army Command and Control Master Plan (AC^{2}MP). Specific TACIP objectives are:

a. Support the development of objective command and control systems by aligning field initiatives with the ACCS architecture.

b. Encourage and support user involvement in defining command and control system requirements.

c. Coordinate, resource, and evaluate command and control initiatives.

d. Collect, coordinate, and integrate field experience in command and control initiatives to permit better definition of user requirements.

e. Use results of field evaluations and experience in the review and modification of existing requirements documents.

f. Identify and recommend command and control systems for near term fielding.

g. Disseminate information on the initiatives to Army units worldwide.

h. Facilitate the coordinated transition of TACIP-generated materiel requirements into the regulatory US Army materiel acquisition process.

During 1983 and early 1984 TACIP was involved in the development, fielding, funding, and evaluation of numerous initiatives. During the Command and Control System Program Review (C^{2}SPR) II held in July 1984, the question was raised as to whether it was time to stop the "1000 flowers blooming" referring to the development of initiatives. The Vice Chief of Staff of the Army decided that the effort should continue, and TACIP should increase its efforts to gather and disseminate information on the initiatives. At this time (1985), the TACIP program is being phased out. The needs which TACIP was created to serve will remain valid, however, and the C^{3}I Directorate of CACDA will continue to perform the functions of TACIP listed above.

2.4. The Army Command and Control System

The Army Command and Control System (ACCS) program, the joint responsibility of the TRADOC and AMC commanders, encompasses the entire Army. The ACCS architecture, as described in the 1985 Army Command and Control Master Plan (AC^2MP), can best be described as an integrated system of systems which, as it evolves, will provide the capabilities required to assist commanders and staffs at all echelons in the command of forces and control of resources. In its broadest context, the ACCS is time independent and supports all Army functions in peacetime, in the transition to war, and in wartime. It contains four interrelated components:

1. The Army portion of the World-Wide Military Command and Control System (WWMCCS). WWMCCS was established by the president to provide for command and control of all U.S. forces and integrates the headquarters of each military department, the Joint Chiefs of Staff, unified and specified commands, joint task forces, service component commands, and selected MACOMs.

2. The Department of the Army Command and Control System (DACCS). The DACCS extends communications from Headquarters, Department of the Army, to the headquarters of MACOMs in the CONUS and Army component commands of joint commands located overseas.

3. The command and control systems of Major Army Commands. Within the CONUS, MACOMs employ internal command and control systems to accomplish assigned missions. These systems are designed to meet the needs of the MACOM, and generally each system is unique.

4. The Command, Control, and Subordinate Systems (CCS^2). CCS^2 is the tactical portion of the Army Command and Control System encompassing elements at corps and below.

Figure 2-1 depicts the top-level functional framework for the ACCS architecture and places CCS^2 in context. Each of the four time phased readiness functions of training, mobilization/deployment, sustainment, and employment are shown as they transcend the geographic zones from left to right. Information linkage is shown by connecting lines. CCS^2 represents the Army's battlefield architecture. It is a wartime system and does not include administration or support associated with peacetime functions. It is further subdivided into five functional segments or subsystems which exercise control of resources allocated to the segment. The five functional segments are: (1) maneuver control, (2) fire support, (3) intelligence and electronic warfare, (4) air defense artillery, and (5) combat service support. Each functional segment is served by a control system establishing vertical links between the elements of that segment located at echelons from corps down to brigade level. (Maneuver control and CSS extend to battalion level.) The five control systems are: (1) Maneuver Control System (MCS), (2) Advanced Field Artillery Tactical Data System (AFATDS), (3) All Source Analysis System (ASAS), (4) Air Defense Command and Control System (ADCCS), and (5) the Combat Service Support Control System (CSSCS). MCS is the most advanced in development of the five systems and will be the first fielded.

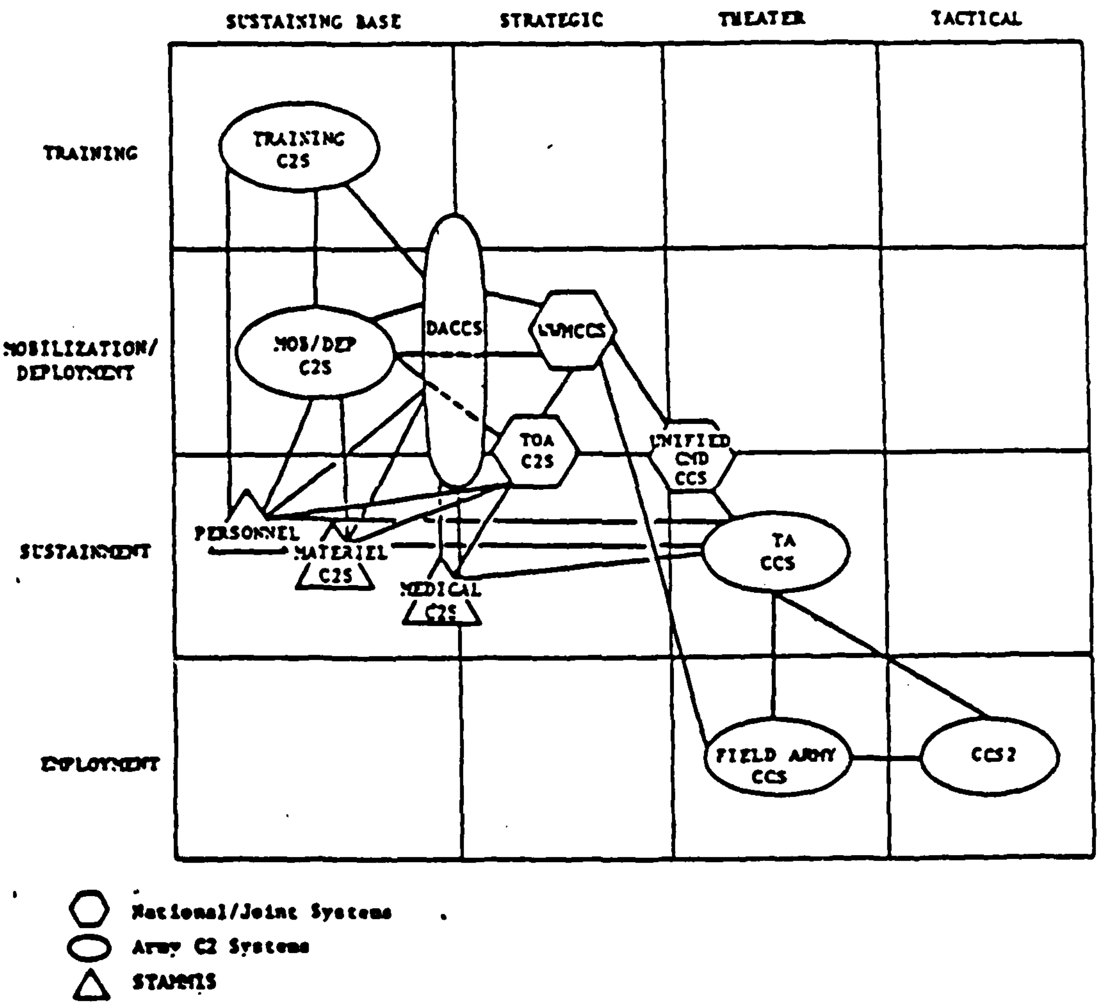


Figure 2-1. ACCS TOP LEVEL FUNCTIONAL FRAMEWORK

Figure 2-2 illustrates the CCS^2 concept at a single echelon. The five pointed star portrays the horizontal integration of information and decisions within a force level. The commander and his staff command and control the force through the maneuver functional node. Information is exchanged with the subordinate maneuver commands as well as with the remaining four functional area control representatives, e.g., DIVARTY commander for FS and DISCOM commander for CSS (represented by the unshaded boxes). The shaded boxes represent the subordinate systems to a specific control system. The subordinate systems process technical and staff information required for the command and control of the functional area.

The Army is evaluating the concept that the ACCS can use a common set of hardware based on three basic classes of equipment: (1) The transportable, or large size, which is vehicle mounted, (2) the portable, or mid-size, which weighs approximately 90 lbs and can be lifted by two men, and (3) the hand held or small size, which weighs a maximum of 11 lbs and is the size of a briefcase. Each of the three classes of equipment will be procured in three hardness requirements: commercial, ruggedized or full mil spec. The government will solicit industry to provide hardware and logistical support to fill all nine categories of size and hardness. Depending on criticality of mission and location on the battlefield, units will receive equipment with appropriate degree of hardness. Three hardware components have already been developed:

1. Tactical Computer System (TCS)

2. Tactical Computer Terminal (TCT)

3. Tactical Computer Processor (TCP)

Each of these systems are multi-purpose devices capable of performing numerous command and control functions. The TCS, and TCT, are militarized, general purpose computers. They provide information processing capabilities and are highly reliable and survivable devices. They are designed to provide continuous C^2 support for tactical operations regardless of the tactical or environmental conditions. The TCP is a non-developmental item (NDI) device and, as such, is less survivable than the mil spec equipment but provides robustness and greater data processing capabilities. The TCP also provides the color graphic capability which is not currently available on the militarized equipment. Technical specifications of the TCS, TCT, and the TCP are shown in Table 2-1.

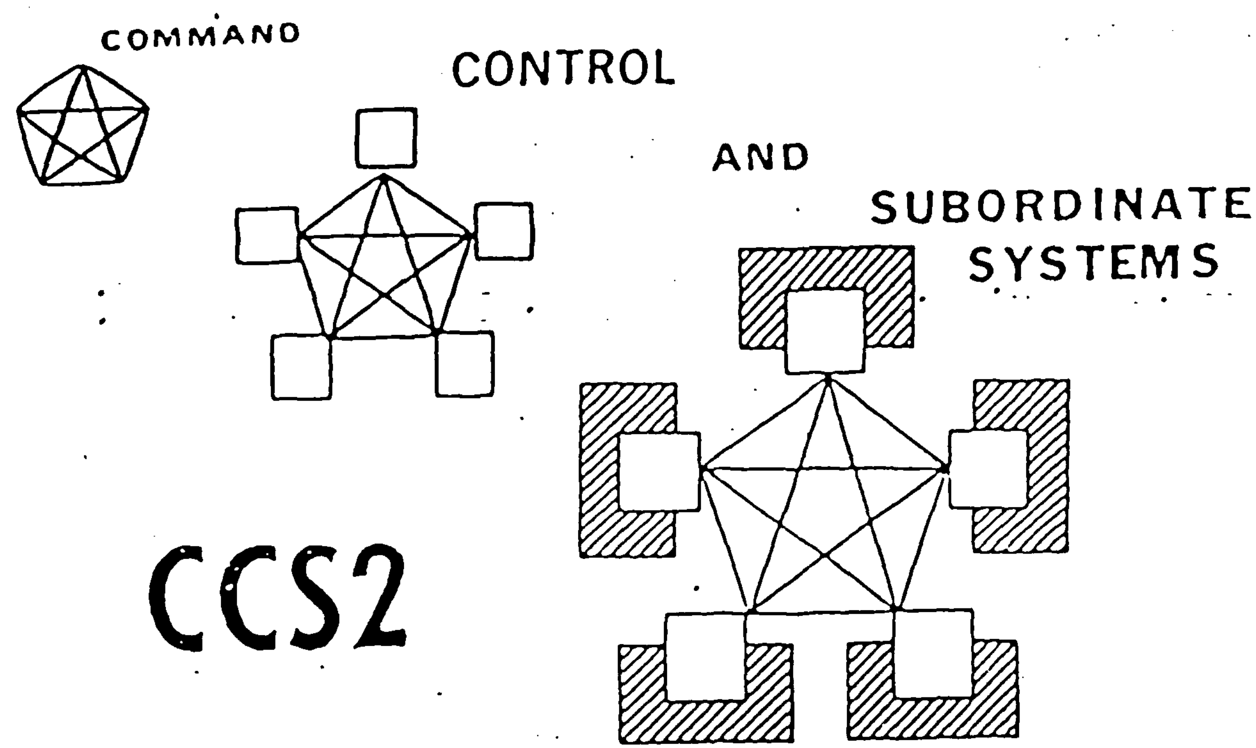


Figure 2.2. COMMAND, CONTROL AND SUBORDINATE SYSTEMS

Table 2-1.

MCS Hardware Device Description

	TCS	TCT	TCP
Processor	1666BV3 16 BIT	M68000 16 BIT	M68000 16 BIT
RAM	1 MB	1 MB	1 MB
Secondary Storage	8 MB	600 KB	55 MB
Communication Channels	12	2	2
Printer	Thermal	Thermal	Thermal
Type Screen	Plasma	Plasma	CRT/Touch Sensitive
Screen Size	8 1/2" x 8 1/2"	8 1/2" x 8 1/2"	8 1/2" x 8 1/2"
Weight	972 lb	519 lb	844 lb
Cubit Feet	41	22	44.5
Operating Temperature	-40 - 130°F	-40 - 130°F	32-110°F
Power	110-240 AC 28 VDC	110-240 AC 28 VDC	110-240 AC 238 VDC
Power Consumption	295 watts	295 watts	800 watts

2.5. The Maneuver Control System

MCS is a corps-wide system which will provide automated support to the commander and his G-3/S-3 staff. It is employed at both heavy and light units, at echelons from battalion to corps. The maneuver functional area includes Armor, Infantry, Aviation, Signal, Engineer, Military Police, NBC, and Echelons above corps units. MCS will have automated interfaces with the control systems of the Fire Support, Air Defense, Intelligence and Electronic Warfare, and Combat Service Support functional areas. The MCS will serve as a model for these four remaining control systems and the MCS program will provide an interim automation capability by distributing automated devices to these functional segments at corps and division level. As the functional areas begin to field their objective systems, they will replace the interim devices.

Central to MCS operation is its data base management system. Messages are entered by selecting the appropriate Army Command and Control System/Message Text Format (ACCS/MTF) and filling in the requested information. By means of prompts, the MCS assists the operator in composing the message. Upon receipt of a message, the MCS Data Base Management System examines the messages, identifies the important items of information and enters these items into the data base of the MCS device. Queries to the data base may be operator initiated or may result automatically as a result of a previously entered Standing Request for Information.

Although the Main CP is the primary focal point of command and control at each echelon of force, the TAC or Rear CP must be capable of assuming the principal command and control functions for the force in the event of the failure or destruction of the Main CP. The MCS provides this capability to each level of force by replicating the contents of the G-3/S-3 operations database at three locations for the corps and division echelon (i.e., Main CP, TAC CP, and Rear CP) and two locations for the brigade and battalion echelon. In the event the commander is unable to command from any of the three principal force level CPs, he can still exercise command and control of his force from any of his major subordinate commands (MSC). Each force level MSC maintains its parent units operational graphics, battle resource status, and intelligence situation. Information availability at a MSC can be expanded by reconstituting the force level MCS database at the MSC or by querying other C^2 automated systems for specific items of information needed.

In addition to data base management, the data processing capabilities of the MCS include the creation of spreadsheets and graphics. Information is presented in the form of color decision graphics of three categories: operations, battle resources, and intelligence. Figure 2-3, 2-4, and 2-5 furnish examples of the three categories of display. The actual displays use the colors red, green, and amber to highlight the information and may be presented at various levels of detail. Map graphics may also be displayed at various scales 1:25,000 to 1:250,000 (standard military map colors) and the viewing area may be focused to a particular area of interest. The graphic displays are fully interactive with the data base; tactical information from the data base may be overlaid on the map graphic. The major changes to MCS design resulting from the merger with DCCS were the addition of integrated color graphics and color decision displays, force level staff integration, key information requirements for the commander, and the distribution of terminals at battalion level.

The development and maintenance of system software for MCS, as well as the four other control systems of CCS^2, is the responsibility of the CECOM Software Development Support Center (SDSC) located at Fort Leavenworth, Kansas. Each MCS user will receive three identical sets of removable storage media, one for wartime use, one for training use, and an additional backup set. SDSC, CECOM is also responsible for updating the software yearly, conducting verification tests, and distributing the updated software to MCS users. The software versions will be released annually, in July. Each version provides additional capabilities and functions to the MCS user based on user recommendations, requirements, and reactions to previous MCS software versions. The following chapters of this manual provide practical advice to aid users in the important task of developing ideas, analyzing concepts, and defining requirements in a manner which will be of most value to the software developers.

Automation of tactical operations has made a slow but steady progress since the end of World War II and will show accelerated development in the late 1980s and 1990s. The potential is so great, it seems inevitable that applications of automation will enable the U.S. Army to achieve modes of operation which can scarcely be envisioned today. MCS, the other control systems of CCS^2, and their evolutionary successors will soon provide what LTG R.W. RisCassi (Commander of the Combined Arms Center and former Commander of 9th Infantry Division), has termed an "electronic mountain" from which the commander can see the battlefield and control his forces with great accuracy and speed and thus can truly turn within the enemy commander's decision cycle.

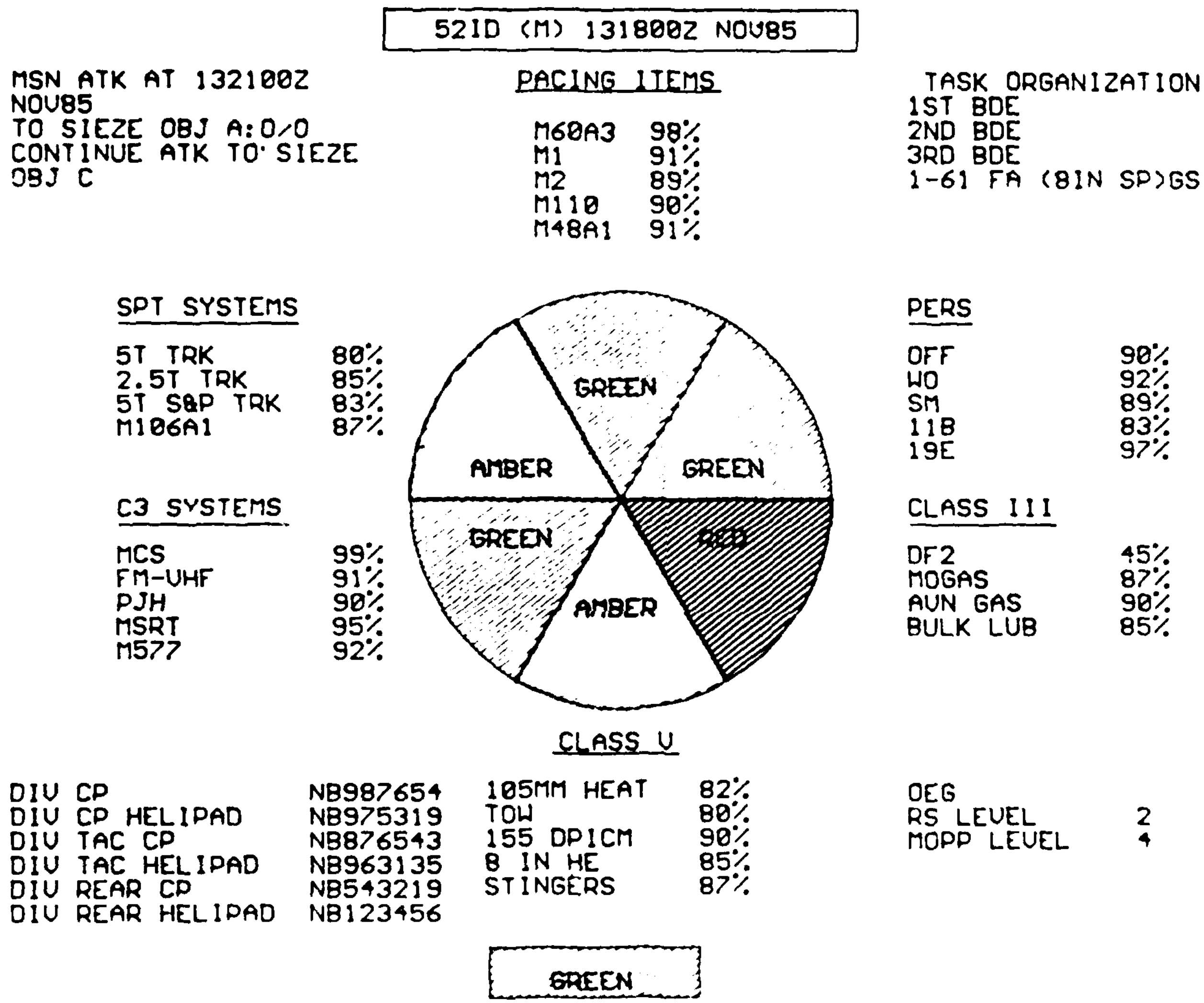


Figure 2-3. MCS Display: Unit Battle Resources.

52 ID (M)	AVENUES OF APPROACH				132030Z NOV 85	
	STATUS	FRIENDLY UNITS	ENEMY UNITS	FRIENDLY ACTIVITY	ENEMY ACTIVITY	FORCE RATIO
A/A #1	RED	3 BDE	345 MRD 9 TK DIV	WITHDRAW	ATTACK	1:7
A/A #2	GREEN	AVN BDE	SM INF UNITS	SCREEN	RECON	1:2.5
A/A #3	AMBER	AVN BDE	TK REGT (UNK)	GUARD	PROBING	1:4
A/A #4	AMBER	2 BDE	28 MRD	DEFEND	ATTACK	1:3.5
A/A #5	AMBER	4 BDE	66 MRD 57 IND TK BN	DEFEND	ATTACK	1:3
A/A #6	GREEN	CAV SQDN	NO CONTACT	MOVEMENT TO CONTACT	NO CONTACT	NO CONTACT
A/A #7	GREEN	CAV SQDN	SM INF UNITS	MOVEMENT TO CONTACT	HASTY DEFENSE	2:1
A/A #8	RED	1 BDE	245 MRD 167 MRD	DELAY	ATTACK	1:6.5

Figure 2-4. MCS Display: Individual Avenue of Approach.

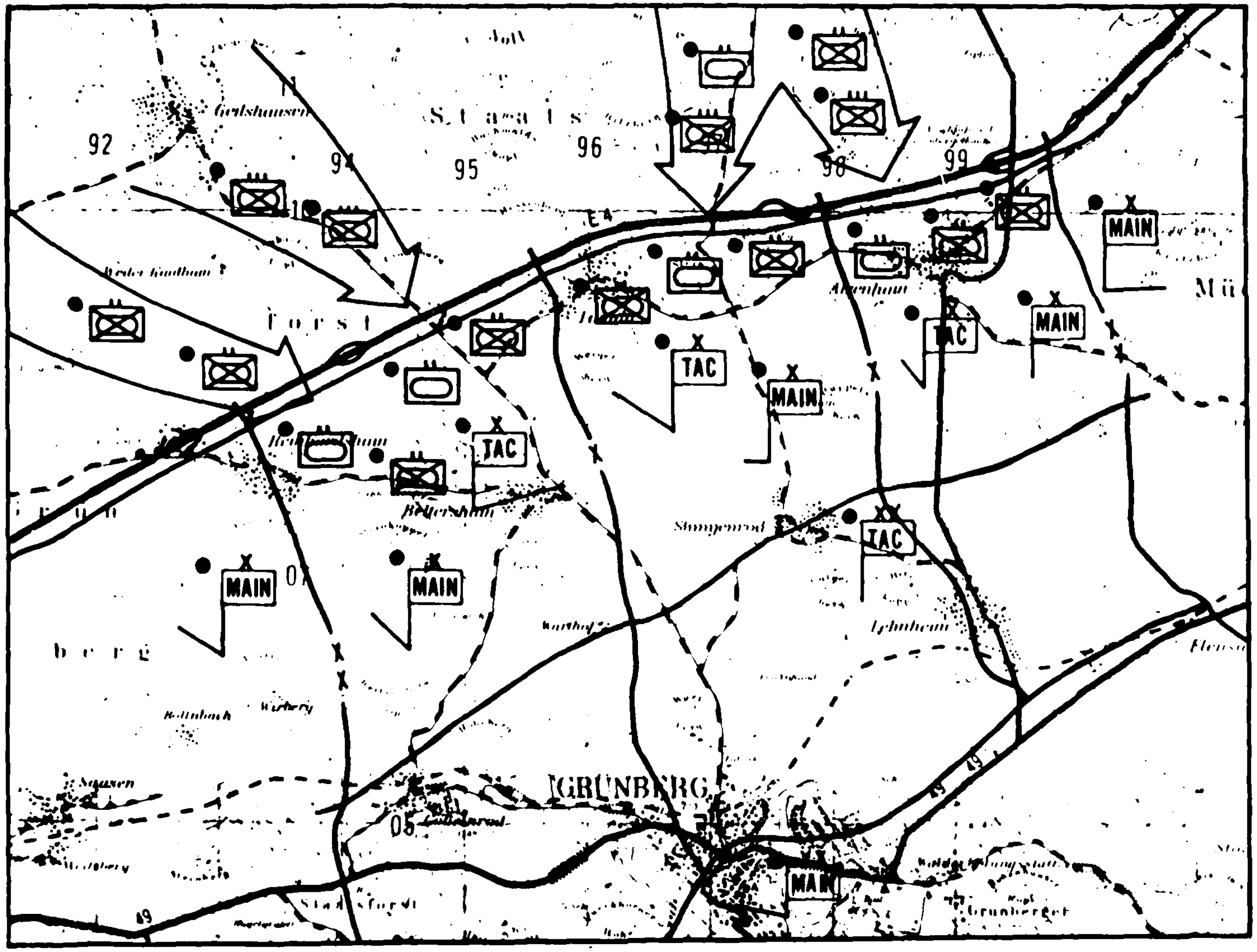


Figure 2-5. MCS Display: Area of Operations.

CHAPTER 3: BASIC GUIDELINES FOR ORGANIZING THE EFFORT

The following suggestions are based on observations of and discussions with units in the field which have attempted to incorporate automation in their operations. They include the concepts that seem to work best in assigning the required personnel and organizing the effort. The suggested outline will have to be modified depending upon the scope of the project. If you are submitting requirements to the CCS[2] or adapting software which has been developed by another unit you will need considerably less technical support than if you are developing an entire application.

As in organizing any such wide-ranging effort, the key factor is getting the right people assigned, people with the required skills, and time to devote to it. Basically, three different groups of personnel are of concern for this effort:

- The Users: These must include:

  - The commander and senior staff who are the ultimate users of the tactical information system and will be the principal beneficiaries of improvements in staff operations.

  - Other members of the staff whose activities will be affected or changed by computer support.

- The Technicians: These are the experts in both hardware and software. They know, in a technical sense, both the capabilities and limitations of automation.

- The Change-Agents: These are those few rare individuals who can speak both "militarese" and "computerese" and thereby facilitate communication between the first two above.

Of the three classes of personnel cited, the technicians are the most obvious shortfall in your current TOE. There are three possible sources for such hardware and software expertise:

- The Force Modernization/Force Development (FM/FD) personnel assigned to your unit.

- The Automation Management Office or Officer(s) (AMO) assigned to your unit.

- Contractor support.

The first two groups named above operate differently in different commands, so you will have to adjust your requests to the local ground rules. FM/FD personnel have been trained in system analysis and may or may not have extensive ADP experience in their backgrounds. AMO personnel, on the other hand, have definitely had extensive training and experience in automation, although they have been primarily concerned with some of the large, centralized data processing systems.

The change-agents are the key ingredient, forming the bridge between the other two groups. The successful implementation of computer support to the system is a classic example of the joint effort of two completely different kinds of expertise. Only military experts understand the true nature of what the system is trying to accomplish and its operating environment. The technical expert in hardware and software, on the other hand, is completely familiar with the capabilities and limitations of automation but has difficulty expressing these in the operational terms familiar to the military expert. Getting these two groups to communicate is the real key to producing a useful system design which is acceptable to the user. This process can be expedited by making available the few individuals who have even limited expertise on both sides of the fence. Frequently these will be officers who, even though they are relatively junior and have limited staff experience, have had enough exposure to automation so that they can talk to the technicians. Such an individual can act as an expediter or catalyst to get the dialogue between military and technical experts started and, in effect, to translate from one set of expertise into the other. Top-down or command emphasis is the key to making this rare resource available even on an ad hoc basis.

Figure 3-1 shows one suggested way in which personnel from the above groups can be organized. It shows a steering committee and a project officer with direct access to the office of the CG/CS. The steering committee is chaired by the CG/CS; members include the coordinating staff chiefs and the project officer. The latter can be accompanied by the senior technical person. Under the project officer is a user group with representatives from the affected staff sections and one or more senior technicians -- which ones to be determined by the application being defined. Also under the project officer is a Technical Group including the technicians and representatives from the immediately affected staff sections -- which ones to be determined again by the application under development. The project officer must, for such an organization to be effective, be of the change-agent type. The more of these that can be identified and assigned throughout this organization, the more rapidly the users and technicians will be able to function together effectively. It is most important to impress them with the idea that their mission is to make data processing technology useful to the user and to translate military requirements into terms the technicians can understand. Their function is not to become system salesmen.

Successful introduction and implementation of automation support for the C^2 system is based on the application of the following operational principles:

- <u>You must first develop a system concept</u>. Just as a successful OPLAN must be based on a carefully selected, clearly enunciated concept of operations, so also must the initial implementation (and subsequent iterations) of automated support be tied to a carefully developed concept of "information operations" when the C^2 system is supported with automation. The system concept must satisfy the requirement in the same way that the concept of operations must provide for the accomplishment of the mission.

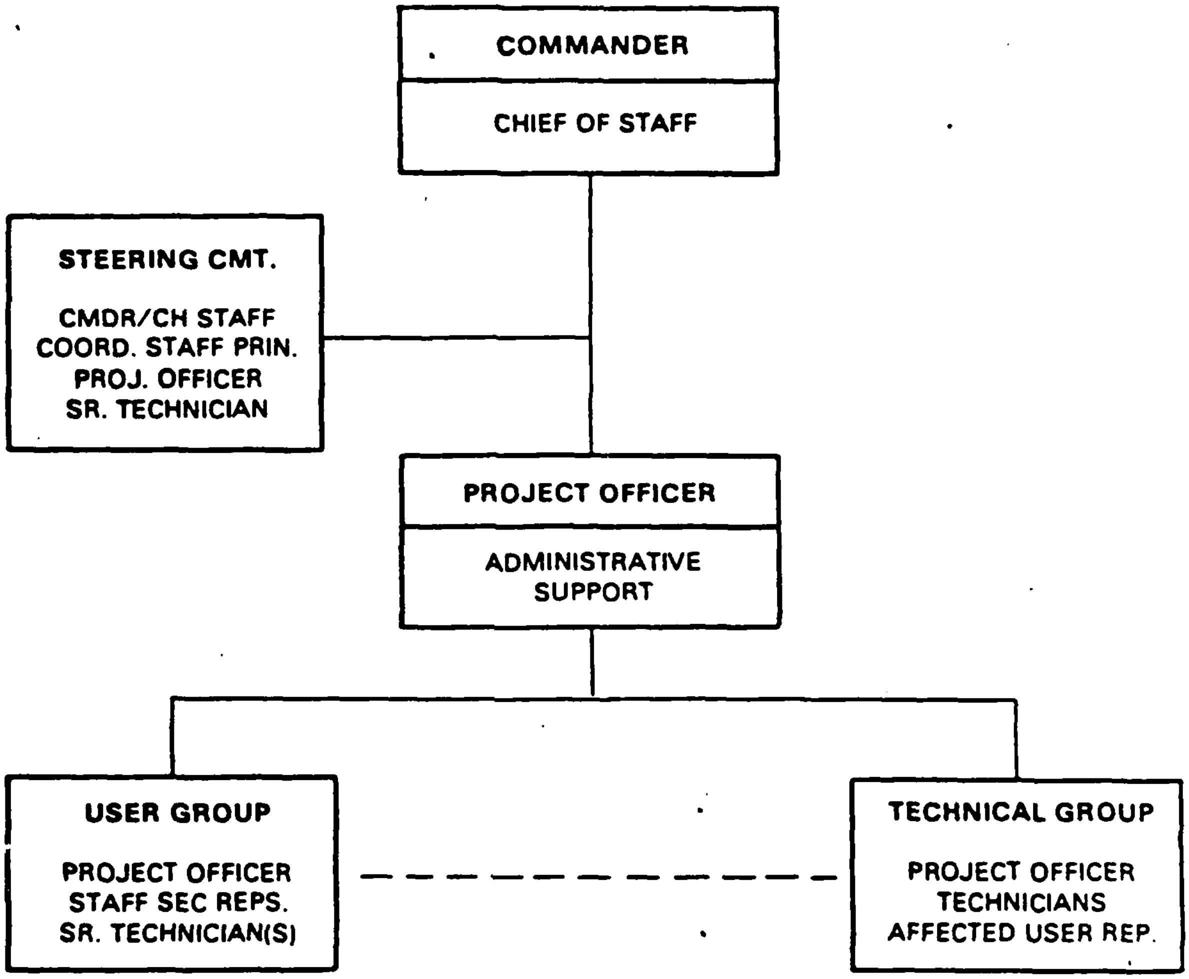


Figure 3-1. A SUGGESTED OVERALL ORGANIZATION

• Commander and senior staff must be personally involved. No change to the C^2 system -- and the introduction of automation will introduce some profound changes -- can succeed without the personal involvement of the commander and senior affected staff officers. After all, the C^2 system exists solely for the purpose of facilitating the making of decisions by the commander and senior staff; it is their system; it must help them solve their problems in their unique mode of decision making. Unless they have helped develop the concept and have interest in its implementation, the concept will fail.

• The effort must be coordinated. A great deal of work might be saved by first investigating what other units have accomplished. The 1985 C^2MUG Software Catalog, published by the Communications-Electronics Command (CECOM) at Fort Leavenworth, Kansas lists 110 software applications which were developed by the military and are available without charge. Automation Management Offices, in units similar to yours, will also be able to tell you what has been done by that unit. Even if you are breaking new ground, be sure to coordinate your effort through C^3I Directorate, Combined Arms Combat Developments Activity at Fort Leavenworth, to make sure your initiative is aligned with ACCS architecture. CACDA also can provide support in defining C^2 system requirements, information on the initiatives of Army units worldwide, and assistance in conducting field evaluations.

• Automation must be integrated into total system operation. There is much more to the introduction of automated support than merely making data processing gear available to the staff. Even though the initial concept may be limited to providing support for only one or two applications, the impact on the remainder of the system of providing that limited support must be assessed if the potential benefit is to be in any way exploited.

• Implementation must be phased in gradually. Even though any degree of automation requires a total system evaluation, the concept implementation must be carefully phased so that the effort does not exceed man, machine, or system capabilities at any stage. It is far better to have potential customers waiting for an application than to promise something you can't deliver.

• System development must be an evolutionary process. Phased implementation, in turn, requires evolutionary development. Establish initial goals, develop the needed support, try it out, improve it and then go on to new goals. It should be noted that the development of a C^2 system will never be finished or completed.

In addition to the guidelines enunciated above, one needs to follow a logical sequence of stages and tasks in implementing the effort. Such a sequence is provided by Figure 3-2 which is sort of a roadmap. It lists five stages which should be followed for each incremental application of automation to the C^2 system, indicates who has the lead for each stage, and shows the tasks required.

Figure 3-3 shows the suggested involvement by the Commander, Chief of Staff and Senior Staff in the task sequence portrayed in Figure 3-2. It indicates the nature of each contact and its purpose. The contacts with senior users

STAGE	LEAD	TASKS
CONCEPT DEVELOPMENT	USER	• DEFINE COMPUTER AIDED SYSTEM GOALS • ANALYZE REQUIRED INFORMATION PROCESSES • SIZE & PHASE PROPOSED APPLICATIONS • DEVELOP TOTAL SYSTEM IMPACT (SOP) • PRIORI' ZE APPLICATIONS
REQUIREMENTS DEFINITION	USER (CHANGE AGENT)	• DEFINE DETAILED MAN-MACHINE INTERFACES
INITIATE DEVELOPMENT	TECHNICIAN	• DEVELOP SOFTWARE • INITIATE OPERATOR TRAINING • MODIFY DETAILED SOP • DEVELOP PLAN FOR DEMONSTRATION AND TRIALS
DEMONSTRATION & TRIALS	USER/TECH	• DEMONSTRATE GOALS ACHIEVED • IMPROVE TOTAL SYSTEM
REPEAT ABOVE FOR "IMPROVED" SYSTEM	USER	• REPEAT FOR NEXT APPLICATION

Figure 3-2. ROAD MAP FOR ORGANIZING EFFORT

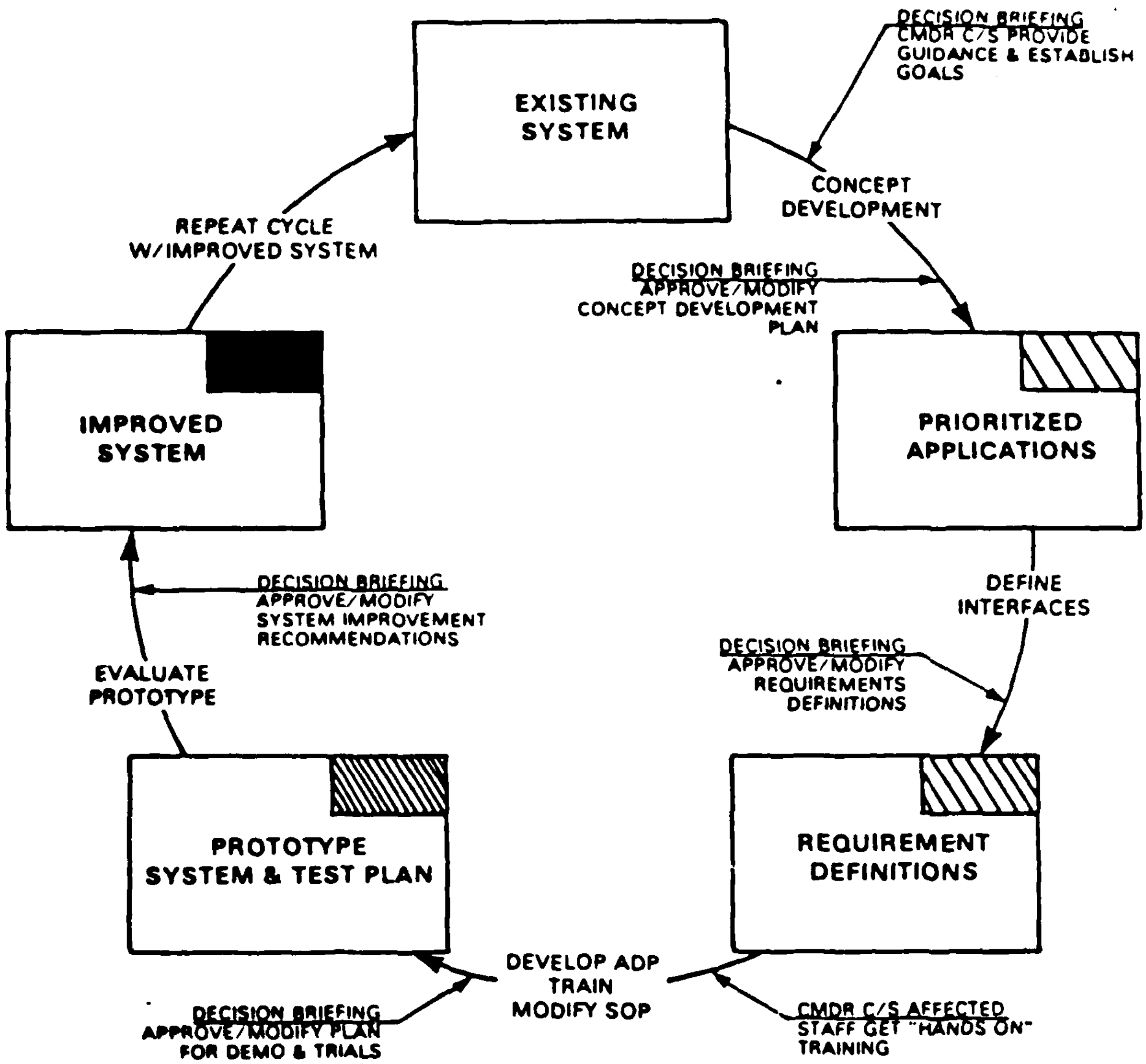


Figure 3-3. SENIOR USER INVOLVEMENT DURING DEVELOPMENT

indicated in the figure are the absolute minimum; other progress briefings are clearly indicated for some of the longer stages such as concept development and software/system development.

The goals, i.e., the output products, selected in concept development for improvement through computer support must be of major concern to the commander and principal staff. Since the C^2 system exists to support their decision making, they are the principal users and, hence, very properly make the final decisions as to how that system will function and be organized. It is, therefore, of the utmost importance that they select the initial package of staff outputs to be assisted through automation. Furthermore, it is to the commander and senior staff that the improvements achieved must be demonstrated. Therefore, they must also be involved in the selection of measures used to demonstrate that improvement. It is not sufficient to have a top-down approach to system design; there must also be top-down involvement in its implementation or the effort will surely fail.

The initial briefing is certainly the most important since it will set the stage for the entire development. It should take place as soon as possible after receipt of the mission. The project officer(s) should do enough preliminary work so that they can discuss the nature of the effort required, the major capabilities and limitations of automation, and some candidate applications and goals. They should indicate the nature of and estimate the size of the resources required and outline the proposed organization of the effort. Almost as important as the initial briefing is the "hands on" experience during the initial operator training and the later demonstrations and trials. If the initial application to be implemented is to demonstrate improvements achieved through automation, several of this senior group (Commander, Chief of Staff, and senior staff officers) must be involved at the terminals. There is no better or faster way to gain an appreciation of the potential for improvement. The remainder of the briefings are decision briefings at key points in the development cycle.

CHAPTER 4: FLOW CHARTS OF INFORMATION PROCESSING SYSTEMS

Chapter 5 will present a method of concept development, beginning with the search for ideas and tracing, step by step, the refining of the ideas into analyzed concepts for automation. Before presenting that method, this chapter discusses two tools which will be helpful in that process: flow charts of information processing systems, and a method of estimating the potential benefits of automation.

Information processing systems, such as command and control systems, consist of three major components: (1) databases, in which information is stored, (2) functions, which operate on information, changing or reorganizing it, and (3) interfaces, which are connections or routes between functions and databases along which information is transferred. Flow charts illustrate the system, using boxes to represent functions and databases and arrows to represent the interfaces between them. You will need to make flow charts to show how the system you hope to improve operates now, and how it will operate after automation.

If the application involves some decision making aspects, and that will probably be the case, a useful start on the flow charts can be made by dividing the process into five components:

1. Input: information is gathered

2. Pre-decision: information is reorganized for the decision

3. Decision

4. Post-decision: information is organized for output

5. Output: decision is implemented

To illustrate, we will consider the operation of the C^2 system in the TOC, although your application will undoubtedly be more restricted in scope.

For our purposes, the C^2 system is defined to include all commanders, their staffs, and all communications, sensors, personnel, equipment, facilities, and procedures used in planning, directing, coordinating, and controlling the assigned forces. Figure 4-1 is a schematic of the C^2 system at a single echelon of command. The Tactical Operations Center (TOC) is shown as an information processing node, in which information is received as inputs, processed, and generated as outputs. There are a hierarchy of such loops in the military structure. At each echelon the system tries to achieve the set of goals prescribed in its mission.

The major functions which ca e distinguished within the TOC are illustrated in Figure 4-2. Incoming ssages are transmitted by the input function to a raw data base (message file) and the pre-decision function. The input function is responsible for receiving messages, verifying the accuracy of the

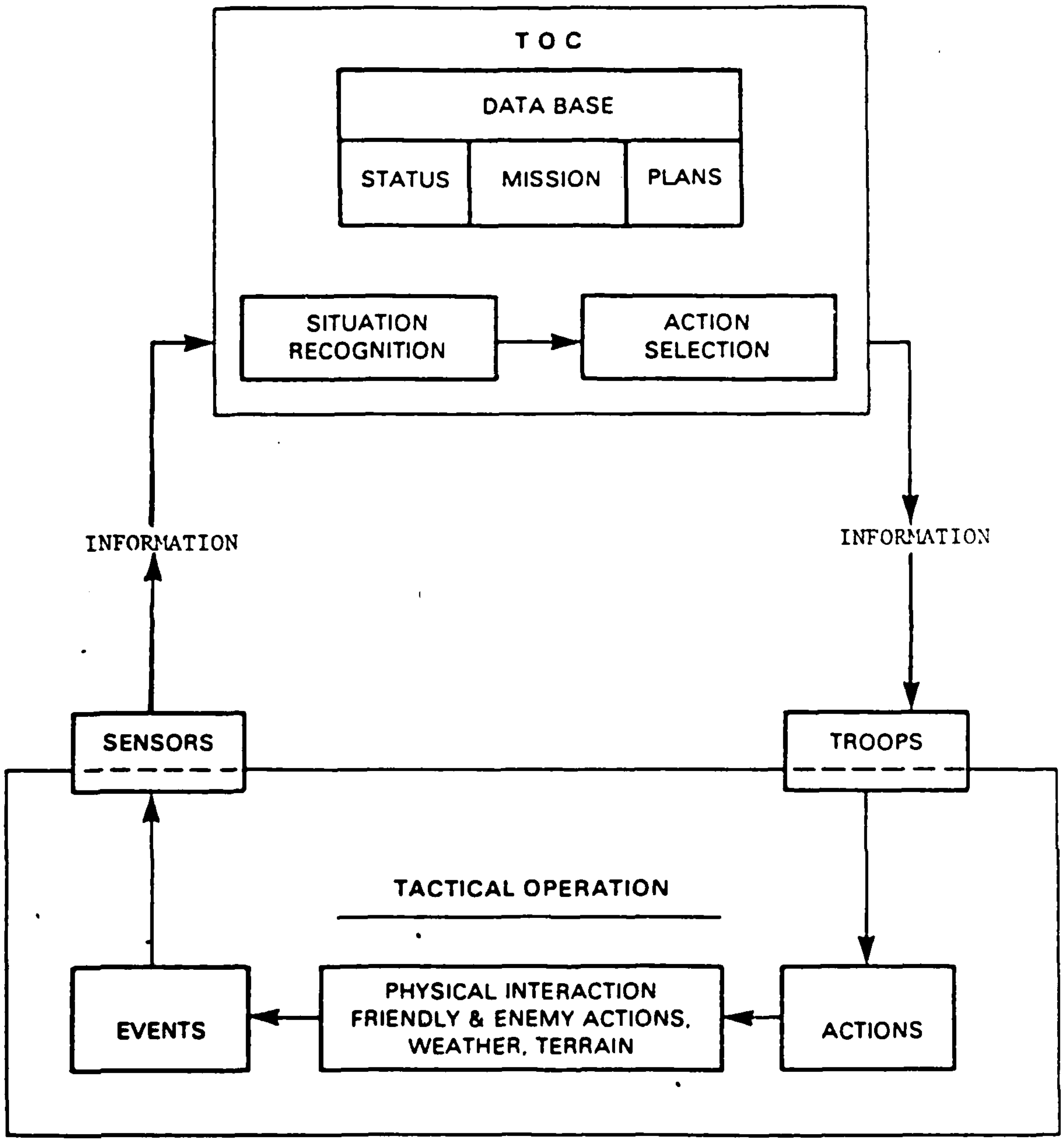


Figure 4-1. A SCHEMATIC OF THE C² SYSTEM

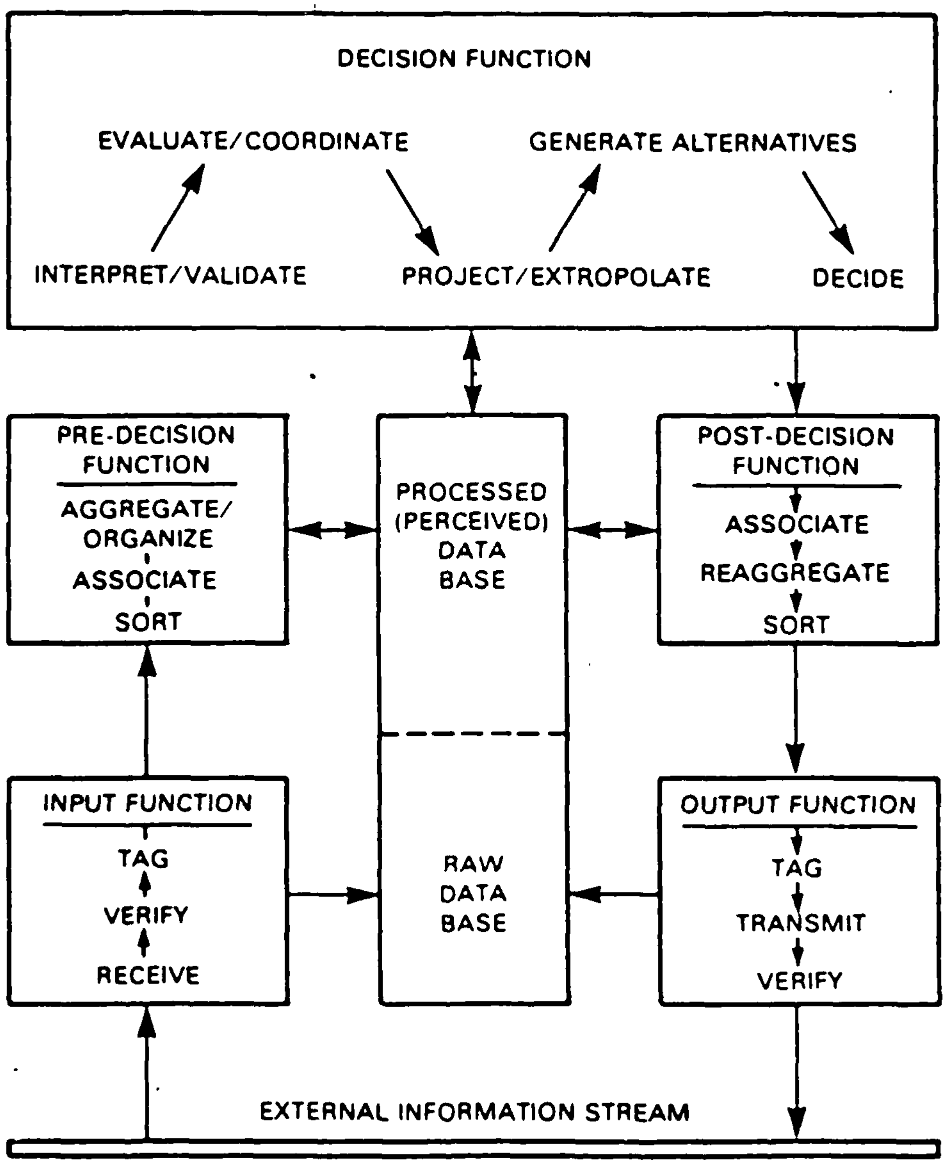


Figure 4-2. COMMAND CONTROL GROUP PROCESSING STEPS

transmission, and tagging the incoming messages with an identifier. The input function further throughputs the messages to a raw data base (message file, staff journal) and to the pre-decision function.

The pre-decision function extracts data from the incoming messages and enters it in structured form into the processed data base, thereby creating and continually updating the useable data base. In the manual (non-automated) mode, section files and displays are instances of the processed data base. The pre-decision function sorts the messages according to some predetermined classification scheme. For example, unit locations are extracted from SITREPs. Sorted information is then associated with other information in the same or a related class, for example, by answering the question "Is the 1st Battalion of the 32nd Tank Regiment part of the 20th Guards Tank Division?". The pre-decision function also organizes and aggregates by combining the associated information and arraying/displaying it in a manner that facilitates the decision processes, for example, updating the Order of Battle.

The decision function extracts information in a structured form from the data base, manipulates and augments the information, adds new structures, makes assumptions to cover the gaps, reinterprets the results, and selects the actions to be implemented. The activities of the decision process illustrated in Figure 4-2 begin with interpretation and validation of the information, whereby cause-and-effect relationships are hypothesized and the probability of these relationships representing ground truth is assessed. (How can the 2/31 Battalion continue to advance at over 5km/hr against two regiments when it has sustained a reported 60 percent casualties?) Next follows a process of evaluation and coordination to determine whether the perceived situation warrants consideration of taking further action or of sharing the perception with another command control group. (Does the gap apparently opening up on our right flank warrant issuing a frag order, or notifying the adjacent unit, or both?) Projections and extrapolations are made to estimate probable future situations based on current or predicted trends. (Where and when must I lay on the next ammunition resupply operation if present expenditure and movement rates continue?) Alternatives are generated concerning friendly and enemy courses of action, possible enemy missions are inferred and enemy capabilities are determined, and finally a decision is reached concerning which of the alternatives considered is most likely to yield the greatest success in accomplishing the mission.

The post-decision function converts decisions into messages and further updates the data base. Relevant information is reaggregated into preparation of an output message. Segments of the message are arranged in the selected format, and distribution is determined. The output function tags, transmits, and verifies the message, and transfers it to the message file and the information stream.

Lest one fall into the trap of regarding the TOC as an entirely reactive entity, one must recognize the arrows shown in Figure 4-2 indicates only information transfers among the components of the TOC. They neither imply that this is a continuous process nor that every input produces an output, nor even that all outputs can be traced to specific inputs. Just as individual human reactions are not necessarily always triggered by external stimuli, group outputs can be triggered by internal stimuli which can vary in complexity from periodic reports triggered by the clock to actions taken as a result of profound insight or hypotheses generated long after the arrival of the latest segment of raw data that has been considered.

We now turn to the question of estimating the potential benefits of automation. We will use the model of TOC information processing developed above to examine the question of the relative capability of man and the machine. Our intuition tells us that there are probably a number of processes that the machine cannot perform, but that there are undoubtedly some which it can perform much better than man. We should also look at the question of which of these processes can probably be performed even better when a machine supports a human.

Such comparison is made in Table 4-1. Listed in the first column at the left are the information processes required for the input, pre-decision, and decision functions. The processes required for the post-decision and output functions have not been repeated since they are the same as for pre-decision and inputs, but in essentially inverse order. The second column lists the dominant characteristics of unaided man in carrying out each process while the third column lists the dominant characteristics of the automated system (machine) by itself. The fourth column rates the potential payoff of combining the complementary capabilities of both man and machine, i.e., of providing computer support to the process.

The table shows that complete automation of the input and output processes offers substantial improvement except for the loss of the "personal" dimension so clearly a basic component of voice communication. The latter can, of course be extremely important in commander to commander ex-changes. Nevertheless, the bulk of the routine traffic could be handled far more rapidly and expeditiously over digital links -- provided the rest of the system could handle the increased information load.

We note that the next three processes, which are invoked for pre-and post-decision processing, are distinctly complementary with respect to man vs machine processing. Only man can provide the basis for sorting and the needed sorting keys, the association algorithms, and the formats and algorithms needed for aggregating and organizing. On the other hand, man is very slow and error prone in the actual conduct of these processes, while the machine is very fast and error free once the needed sorting keys, algorithms, and formats have been provided. Clearly, these are processes which can profit from joint man-machine processing. Fortunately, too, the bulk of the human processing required can be done "off-line," that is, the sorting keys, algorithms, and formats can be developed in advance and stored in the computer. The bulk of this pre-and post-decision processing can therefore be shifted to the machine and the human processor needs to assist only on an exception basis. Note, however, that this also shifts some of the burden to the message originator who must now format or otherwise provide sorting keys.

When we examine the last five, the decision processes themselves, we note that not only are man's creative talents required, but that they must be applied on-line as the information is being processed. On the other hand, the computer provides the ideal medium to be used as a memory and mind "extender" in support of the decision maker. Not only can it retrieve any data item in

Table 4-1. COMPARISON OF MAN AND MACHINE PROCESSING CAPABILITIES

	PROCESS	MAN UNAIDED BY MACHINE	MACHINE WITHOUT MAN	MAN-MACHINE INTERACTION LEVERAGE
INPUT & OUTPUT	RECEIVE, TRANSMIT	COMMUNICATES MOOD OF SENDER	INCREASED EFFECTIVE CHANNEL CAPACITY; HARD COPY	LITTLE*
	VERIFY	SLOW; ERROR PRONE	FAST; VIRTUALLY ERROR-FREE	LITTLE*
	INPUT/OUTPUT TAG	SLOW; ERROR PRONE	FAST; VIRTUALLY ERROR-FREE	LITTLE*
PRE AND POST-DECISION	SORT	CAN SORT ON CONTENT; CAN GENERATE SORTING KEYS; SLOW; ERROR PRONE	CAN SORT ONLY ON KEYS	SIGNIFICANT
	ASSOCIATE	CAN GENERATE ALGORITHMS, BUT SLOW AND ERROR PRONE AT ASSOCIATED OPERATIONS SUCH AS FILE/POST/PLOT/RETRIEVE	LIMITED TO PREDETERMINED ALGORITHMS, BUT VERY MUCH FASTER AND ERROR-FREE AT ASSOCIATED OPERATIONS	SIGNIFICANT
	AGGREGATE/ORGANIZE	CAN GENERATE ALGORITHMS AND FORMATS, BUT SLOW AND ERROR PRONE AT ASSOCIATED OPERATIONS: FILE/POST/PLOT/RETRIEVE/CALCULATE	LIMITED TO PREDETERMINED ALGORITHMS AND FORMATS, BUT VERY MUCH FASTER AND ERROR-FREE AT ASSOCIATED OPERATIONS	SIGNIFICANT
DECISION	INTERPRET/VALIDATE	ONLY MAN CAN FLESH OUT INCOMPLETE PATTERNS AND GENERATE NEW HYPOTHESES AND TESTS FOR THEM	CAN ONLY EXTEND HUMAN MEMORY (ASSOCIATED OPERATIONS) AND FACILITATE HYPOTHESIS TESTING (CALCULATION)	TREMENDOUS
	EVALUATE/COORDINATE	ONLY MAN CAN INTERPRET IN CONTEXT AND GENERATE HYPOTHESES AND INSIGHTS	CAN ONLY EXTEND HUMAN MEMORY AND FACILITATE COORDINATION BASED ON A PRIORI RULE	SIGNIFICANT

*MACHINE CAN PERFORM THESE PROCESSES WITHOUT AID OF MAN.

Table 4-1. COMPARISON OF MAN AND MACHINE PROCESSING CAPABILITIES (CONT'D)

	PROCESS	MAN UNAIDED BY MACHINE	MACHINE WITHOUT MAN	MAN-MACHINE INTERACTION LEVERAGE
DECISION	PROJECT/EXTRAPOLATE	ONLY MAN CAN DEFINE PROJECTION AND EXTRAPOLATION PARAMETERS; INVOLVES HYPOTHESIS GENERATION	CAN ONLY EXTEND MEMORY AND FACILITATES CALCULATIONS	TREMENDOUS
	GENERATE ALTERNATIVES	ONLY MAN CAN GENERATE NEW HYPOTHESES	CAN ONLY EXTEND MEMORY PERMITTING CONSIDERATION OF LARGER DATA BASE; RETRIEVE A PRIORI ALTERNATIVES FOR EVALUATION; FACILITATE RENDERING IN HARD COPY	TREMENDOUS
	EVALUATE ALTERNATIVES AND DECIDE	MAN EXCELS AT STRUCTURING PROBLEMS TO BE SOLVED AND ESTABLISHING BOUNDARY CONDITIONS, MAN MUST MAKE FINAL DECISION	CAN ONLY *PERMIT MUCH* MORE RAPID CALCULATION WITH MORE SOPHISTICATED MODELS, CAN APPLY DECISION CRITERIA MORE RAPIDLY, LESS ERROR	TREMENDOUS

memory, but it can display it in whatever manner the decision maker desires. It can operate on it according to instructions and perform calculations without error, and, finally, it can accept new items created by the decision maker as he develops and tests alternative hypotheses. At a still higher level of sophistication it can store and retrieve both enemy and friendly doctrine to still further assist the decision maker. When stored in the computer with tests and rules for their application, these become artificial intelligence, put at the disposal of the decision maker. The result of this combination provides a tremendous amount of leverage as compared to the decision maker trying to operate with the standard "manual" aids consisting of manually prepared overlays and displays, and oral briefings. Interactive, man-machine decision making not only leads to faster but also to better decision making in that all the available and pertinent data can be accessed rapidly and, together, man and machine can better cope with remaining uncertainty.

The above discussion has demonstrated that automation can help achieve such goals as reducing time lines, providing decision aids, and managing uncertainty of the database. It has, however, also demonstrated that achieving these goals may not be quite as simple as we would like it to be. Any system or organization composed of men and machines really has four distinct variables or dimensions which can be manipulated in order to best accomplish the assigned mission. These manipulable variables are:

- The personnel and human skills available

- The technological "skills" available

- The breakdown into the individual tasks

- The structure, to include the procedures for accomplishing the tasks required by the mission

These four variables are what are being manipulated in any endeavor to improve the functioning of the system. Any such effort involves a whole series of compromises and trade-offs between the capabilities and limitations of the system components. Change any one of these variables; for example, technology, and the compromises previously worked out may no longer be valid. In general, a change in any one requires changes in all the others in order to exploit the potential improvement to the utmost. Think of the profound changes in personnel skills, task assignment, and structure introduced into military forces between 1918 and 1939 by the introduction of the tank and the tactical radio. An example with respect to the C^2 system has already been cited; automation of the input/output processes alone will almost immediately overload the rest of the decision making node. One must never overlook that the tactical C^2 system <u>is a system</u> and that the total system impact on any change must be considered.

CHAPTER 5: CONCEPT DEVELOPMENT

The best ideas for automation of tactical or garrison operations will undoubtedly come from the officers in the field units who are the experts in command and control. Whether the goal is to submit requirements to aid in the evolutionary development of the Army-wide command control, and subordinate systems or to maximize the utility of computer equipment already available by developing smaller in-unit applications, the initial and critical step is the formulation of a detailed concept of automation. Such a concept must include:

- A clear definition of what is to be accomplished through computer support in terms of measurable, demonstrated improvement of some intermediate or final output product of the commander and staff.

- A careful analysis of the processes required to produce the particular staff output product selected above.

- Careful selection of which of the above processes are to be assigned to automation.

- A detailed set of procedures for performing both the machine and human processing required to produce the measurable product. This will, of course, have to be modified as the development proceeds and, most certainly, as a result of the initial trials. It is important to note that this set of procedures will almost certainly be different from the procedures used in manual processing.

The whole notion of having to develop a formal concept of "information operations" is somewhat foreign to us; after all, we have been organizing and training staffs for years without prescribing a detailed set of operational procedures for carrying out the necessary information processes. Such detailed procedures were developed as we needed them. A formal SOP was usually prepared to cover such special requirements as displacement, enemy attack on the CP, nuclear release, chemical attack, and vitally needed reports, but the routine processing took care of itself. FM 101-5 describes the duties, responsibilities, and functions of commanders and staffs and describes in some detail what has to be done. Appropriate TOEs list the assets authorized to perform these tasks. The ARTEPS provide performance standards and, hopefully, personnel assigned are qualified in their MOS.

None of the above documents, however, provide much guidance on how to carry out the doctrinally prescribed tasks other than a few formats for the major staff products and what can be inferred from MOS specified skills. Group members, interacting over a period of time, will develop standard work patterns in which routine and precedent play a relatively large part. This somewhat casual approach to the detailed ordering of the information processing is understandable and reasonably successful when "machine" support is limited to voice and teletype communication, typewriters, manual displays and files, and possibly a copy machine or two. In such a manual system, information processes are all performed by human beings which are among the most highly variable, nonstandard parts from which a system can be formed. Furthermore, humans are almost infinitely adaptable; whenever one or more members of the team change, the rest adapt to the skills, limitations and preferences of the replacements -- especially of the senior members. As a result, no two staffs process information in exactly the same way nor do two shifts of the same staff operate in an identical manner.

The advent of automated support changes all this. Even though software can be made somewhat flexible and adaptive, still, to the degree that information processing is performed by machine, the information system now contains "standard" parts which impose a degree of discipline in system design and operation far greater than was required when it was populated only by people. This does not mean that automation alone can drive your system design. Clearly it must respond to the commander's wishes and accommodate the real world situation. However, without a detailed concept of just how the information processing is to be improved through computer support, the effort will flounder; very little, if any, improvement will result, and many resources and much time will have been wasted.

5.1. Identifying Candidate Applications

The key to getting users to submit original and useful suggestions, regardless of what means are used to elicit them, is to stimulate the user by providing some well thought out "strawmen." People are always more willing to comment on proposals made by someone else than they are to initiate original suggestions -- and in the process of commenting they will frequently be stimulated to come up with some new ideas. The group solicited for suggestions must include the commander and senior staff as well as other members of the staff. Although the suggestions from the commander and senior staff have, ipso facto, priority, the lower level participants may well provide valuable insights and plug gaps in the submissions of their seniors. One possible sequence would be to use a questionnaire to elicit comments and suggestions on a set of applications you have provided as a strawman. Then, after you have listed a modified set of applications based on the questionnaire, convene a brainstorming session to gain a consensus. Anonymous questionnaires are usually preferable.

Each candidate application must be expressed in terms of clearly identified products. In addition to identifying the candidate output which is to be improved, the submission must specify exactly how this product is expressed quantitatively:

- Reduce staff preparation time for this _____ to less than 30 minutes.
- Reduce lag time between input message and _____ to less than 5 minutes.
- Reduce discrepancies between friendly input locations and displayed locations to less than 1%.

If it is not possible to express the improvement quantitatively, the improvement goal must be described in sufficient detail so that there can be no doubt when the desired level of improvement has been demonstrated.

5.2. Applications Analysis

CANDIDATE APPLICATIONS	→	FLOW CHART FUNCTIONS, PROCESSES & DATA BASES IN MANUAL MODE	→	MODIFY CHART FOR AUTOMATION SUPPORT	→	OBTAIN "EXPERT" ESTIMATE OF IMPROVEMENT: DEFINE INTERFACE	→	REFINED LIST OF APPLICATIONS

The candidate applications must now be analyzed to determine:

- Which of the processes required for each application can be supported by automation.

- The probable contribution of each toward the application goal.

- The probable cost in time and dollars.

The suggested way to initiate this analysis is to develop a flow chart of the functions, processes, and data bases required to produce the output(s) identified in the specific applications. The general model of C^2 group processing steps shown at Figure 4-2 provides the building blocks for this effort. Do this initially to show how these outputs are produced in the manual mode. Include all of the processing needed all the way back to the data stream, both in and out.

As an illustration we will consider an example which is similar to the project that was undertaken by the ACCS engineers when it was decided to incorporate force level integration into MCS. We use the example here because it is generic and easily understood. It is unlikely that your application will be as broad or complex. We call our example the commander's briefing project. The commander has expressed the desire that the information heretofore provided him at the morning and evening briefing be made available to him through a computer terminal. He has also seized on the possibility that by this means he can, in effect, receive as much as he wants of the briefing at any time without waiting for a scheduled briefing and the information provided will be current, i.e., represent the latest staff perceptions and recommendations, whenever he requests it.

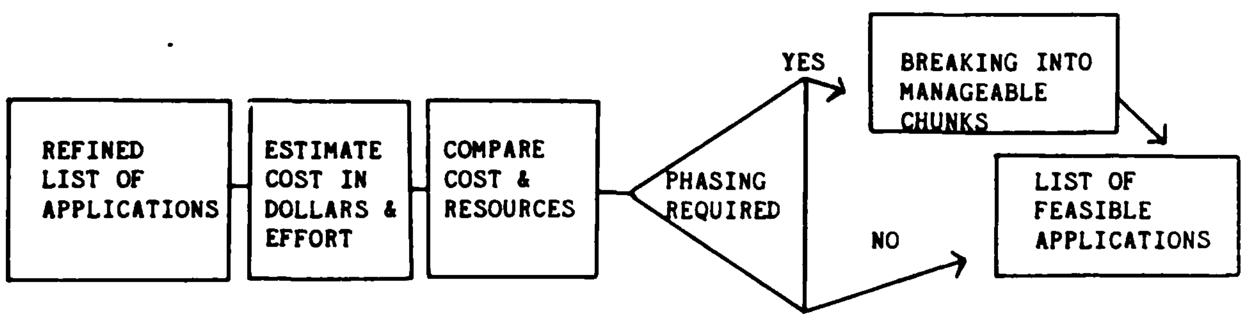
Each staff section must carry out all of the processing shown in Figure 4-2 because many decisions are required in the preparation of the briefing: Which information should be presented? What additional information do we need? What is the most likely interpretation of what we know? What are the most appropriate courses of action? What recommendation should we make? In making these decisions, each staff element is determining what information to include in the briefing and, effectively, creating a special "briefing data base." In the manual mode this briefing data base consists of the briefing maps, overlays, and charts plus the information conveyed to the commander from the memory of the briefing officers. Such a data base covers the entire spectrum of the operations of the command as a whole, but will be less detailed than the processed (perceived) data bases of the separate staff elements.

Figure 5-1 illustrates a flow chart of the information processing required for the briefing for a single staff element. Notice that the lower two thirds of this figure is identical to Figure 4-2 and represents the processing needed to create the staff section's own perceived data base -- its working files and displays. In addition, Figure 5-1 has added another output from the staff section decision processes: the briefing data base. This is, in turn, accessed by the commander's decision processes and further updated to reflect his decisions. It is this briefing data base and access to it both by the commander and staff that we are proposing to automate. It must be noted that Figure 5-1 shows the processing of only a single staff element, in this case, operations. Each of the other coordinating staff sections and special staff elements must go through the same series of processes. Also some of this processing may go on at locations other than the TOC; e.g., the bulk of the G-1 and G-4 sections are usually at Rear.

Also indicated in Figure 5-1 are the major interfaces or data exchanges that need to take place. These have been indicated by letters A through G. In most cases these take place between functions and data bases except for the interface between input/output and pre-, post-decision processing which do not share a common data base.

Your flow chart will have to be modified to reflect how it will be changed when supported by the proposed automation. This will be an iterative procedure as you examine several different candidate processes for automation and recall that an automated data base must be shown separately to support the processes you intend to automate. The major change from the manual flow chart is the identification of the interfaces which will become human-machine terminals. Remember that you must ultimately provide for every data element needed as input into the automated data base and for every desired output.

5.3. Sizing and Phasing



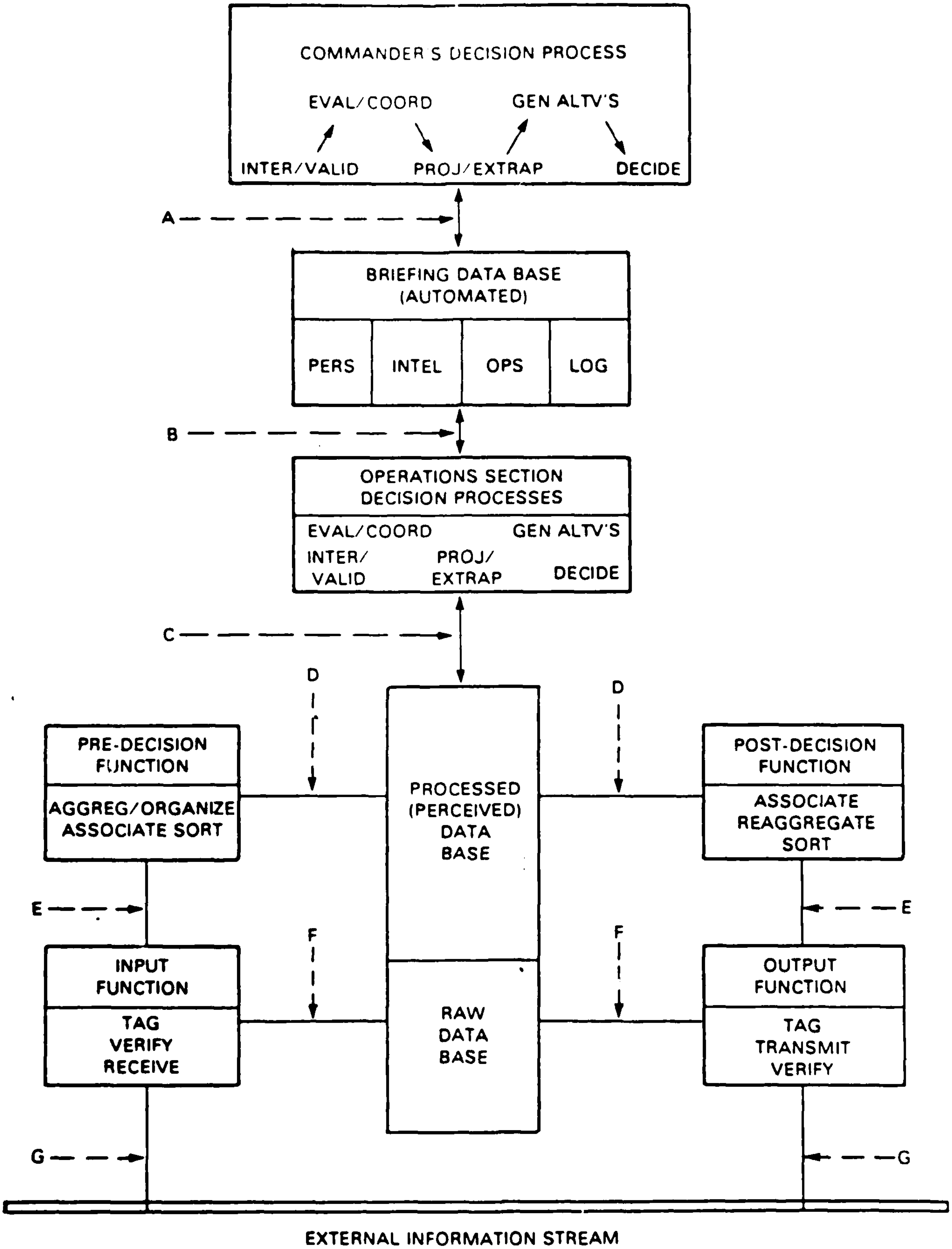


Figure 5-1. OPERATIONS SECTION PROCESSING

For the larger applications such as the Commander's briefing it will be clear that the ultimate goal cannot be achieved in a single iteration. Such a single massive leap into automation is neither practicable nor desirable. Not only would it exceed currently available resources, but, even more importantly, it would require a period of time to plan, design, develop, and implement far longer than available. If improvement of the operation through computer support cannot be demonstrated in some measurable degree during the current tour of duty of the commander and senior staff, the effort will most assuredly have to start all over from scratch at some future time. The effort to provide computer support must be phased. This means not so much curbing the appetite for automation as breaking it into chunks of manageable size. Each application considered should lie well within your resources both in terms of dollars and available technical expertise and it must also be doable and demonstrable within a reasonably short period of time. The initial application should also be selected on the basis that it is a logical first step toward whatever ultimate goal has been established for achievement through computer support.

Defining and phasing the successive applications which will lead you to the ultimate goal that has been established requires that you start with that goal and then develop an appropriate phasing strategy by which that goal can be reached.

There are some basic system design rules which should be observed in implementing the strategy:

1. Each successive application (not just the first) must demonstrably improve the performance of the C^2 system. In general, this means that the application must be tied to one or more staff products and specified quantitative improvements in their production.

2. In planning successive applications, each should exploit the capabilities already provided by its predecessors. It cannot be repeated too often that the incremental introduction of automated support means the incremental transition from all-manually created to automated data bases. The latter should, of course, be common (accessible by anyone who needs the information) and distributed (for survival). Successive applications must provide for an orderly transition from one to the other with minimal duplication of labor at each intermediate stage.

3. Use commo channels only for the transmission of dynamic information -- never for the transmission of static information which should be stored locally. Do not use the commo system to transmit complete formats, displays, or charts. Instead, transmit only that information required to keep the data elements in the data base current. Ideally the user should be able to display the data he needs in a format of his choice; the system retrieves the updated data elements needed to complete it. As an obvious example, transmit only the data on the overlay -- not the entire map underneath it.

4. A top-down approach to providing automated support, i.e., beginning with products that require the decision processes, then the pre- and post-decision processes, and finally the input and output processes, will lead to a more efficient system design. Numerous visits to units participating in the TACIP program have emphasized this principle. Defining the commander's needs

first makes the determination of what data are needed, where to get them, and how to sort, correlate, and aggregate them for presentation a relatively straightforward task. Starting at the bottom with "electronic mail" tends to include every possibility at the lower levels and then ignore those not needed as the system is developed upward.

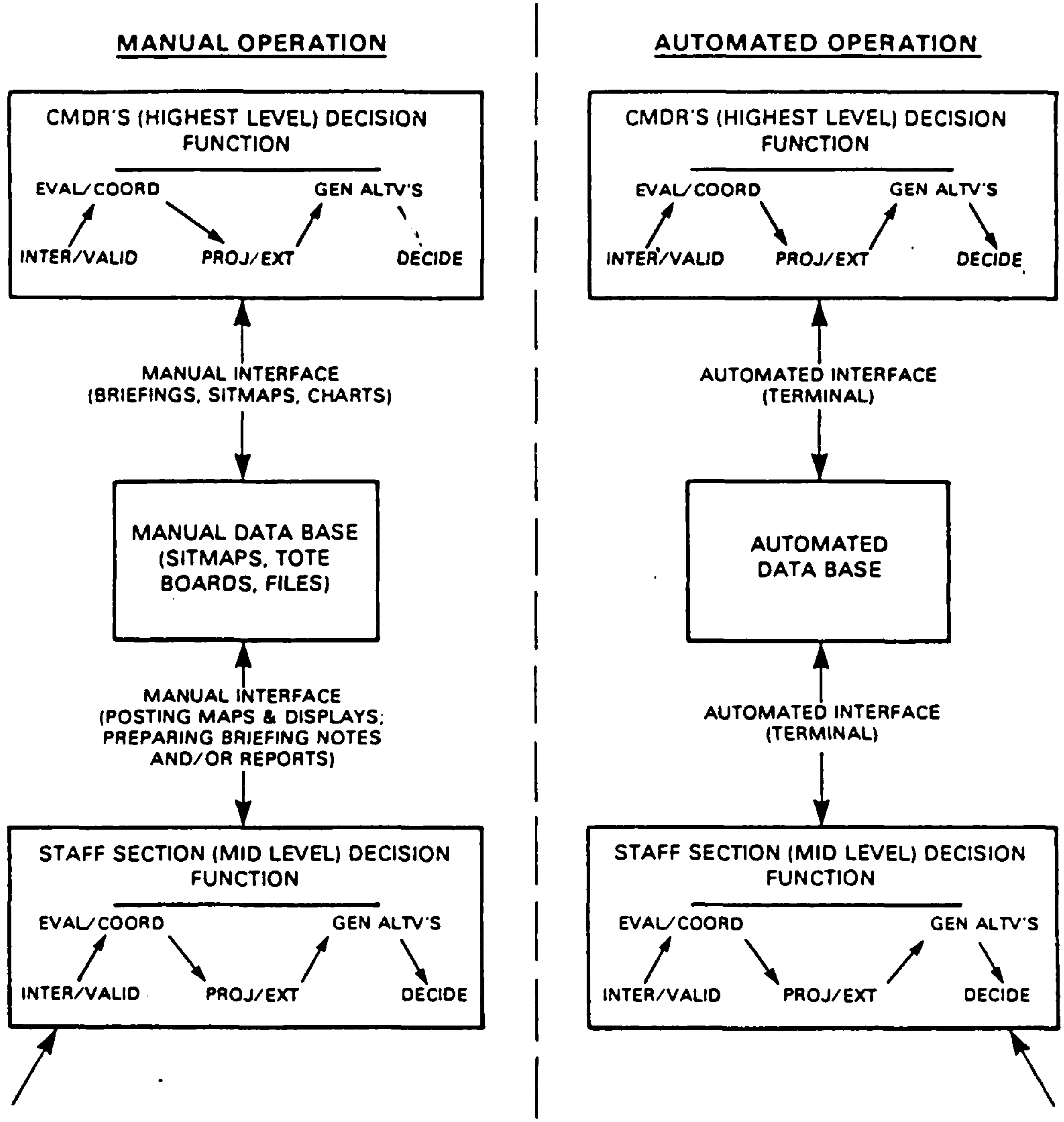
The above discussion has concentrated on the question of defining a logical progression of applications aimed at the achievement of a larger goal. For such larger applications it will be necessary to break the job down into a series of steps with intermediate goals for each. This, in turn, requires drafting a series of flow charts, one for each product that is to be produced with automated assistance. Figures 5-2, 5-3, and 5-4 have been designed to assist you in drafting the flow charts after you have determined the function level involved. Figure 5-2 shows partial automation to assist the commander's decision function. It indicates that the information flow between the commander and the staff is partly through an automated data base and partly manual. For example, if only the staff estimates and the commander's guidance were to flow between commander and staff via automated terminals, any additional decision processing by the commander (additional alternatives, answering other "what if" questions) would have to flow over the manual interfaces indicated. Figure 5-3 similarly presents the middle or staff processing level of the C^2 Information processing/decision making system. Figure 5-4 similarly presents the lower layer, i.e., the input/output and pre-/post-decision processes which might be partially automated by means of "electronic mail." Your flow charts are not finished until you have identified every information transfer across each automated and manual interface needed for the product under consideration. A technique for further identifying the needed interfaces and displaying them is discussed in Chapter 6. A logical development sequence can now be determined by grouping together into single applications those products which share the largest number of automated data transfers. Applications can, in turn, be sequenced by adding them in the sequence which provides assistance to the largest number of high priority products with the smallest addition of automated data transfers.

Several things will be noted about flow charts constructed in this fashion:

- All flow charts for products that involve the same functions will be essentially identical; the differences will lie in the needed data exchange.

- As you automate more and more products in one of the large, phased applications, the data flow will tend to flow more and more over the automated channels and the manual exchanges will tend to disappear.

- Although shown as separate data bases for each of the function levels, this is a purely functional representation. The automated data bases at each level need not be physically separated, nor physically colocated with the information functions and processes they support (as do the manual data bases).



CHARACTERISTICS:

- MANUAL OPERATION REQUIRES COLOCATION OF CMDR, DATA BASE, & STAFF
- HENCE, CMDR'S DECISION FUNCTION MUST BE SCHEDULED (DAILY BRIEFINGS)

CHARACTERISTICS:

- LENDS ITSELF TO DISPERSED LOCATION
- HENCE, CMDR'S DECISION FUNCTION CAN BE INVOKED AS REQUIRED (CONTINUING ESTIMATE)

Figure 5-2. PARTIAL AUTOMATION — CMDR'S DECISION FUNCTION

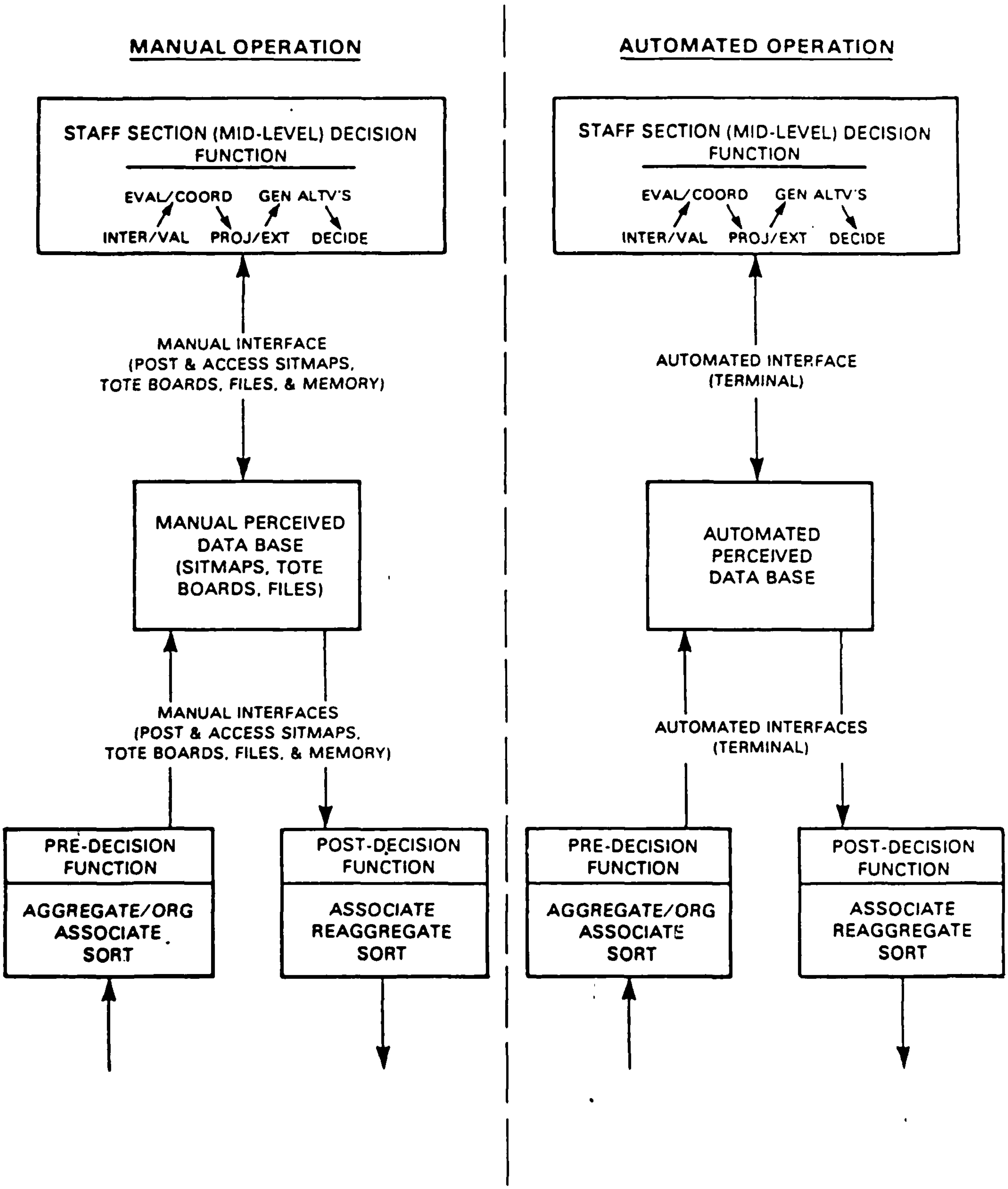


Figure 5-3. PARTIAL AUTOMATION — STAFF DECISION AND PRE-/POST-DECISION FUNCTIONS

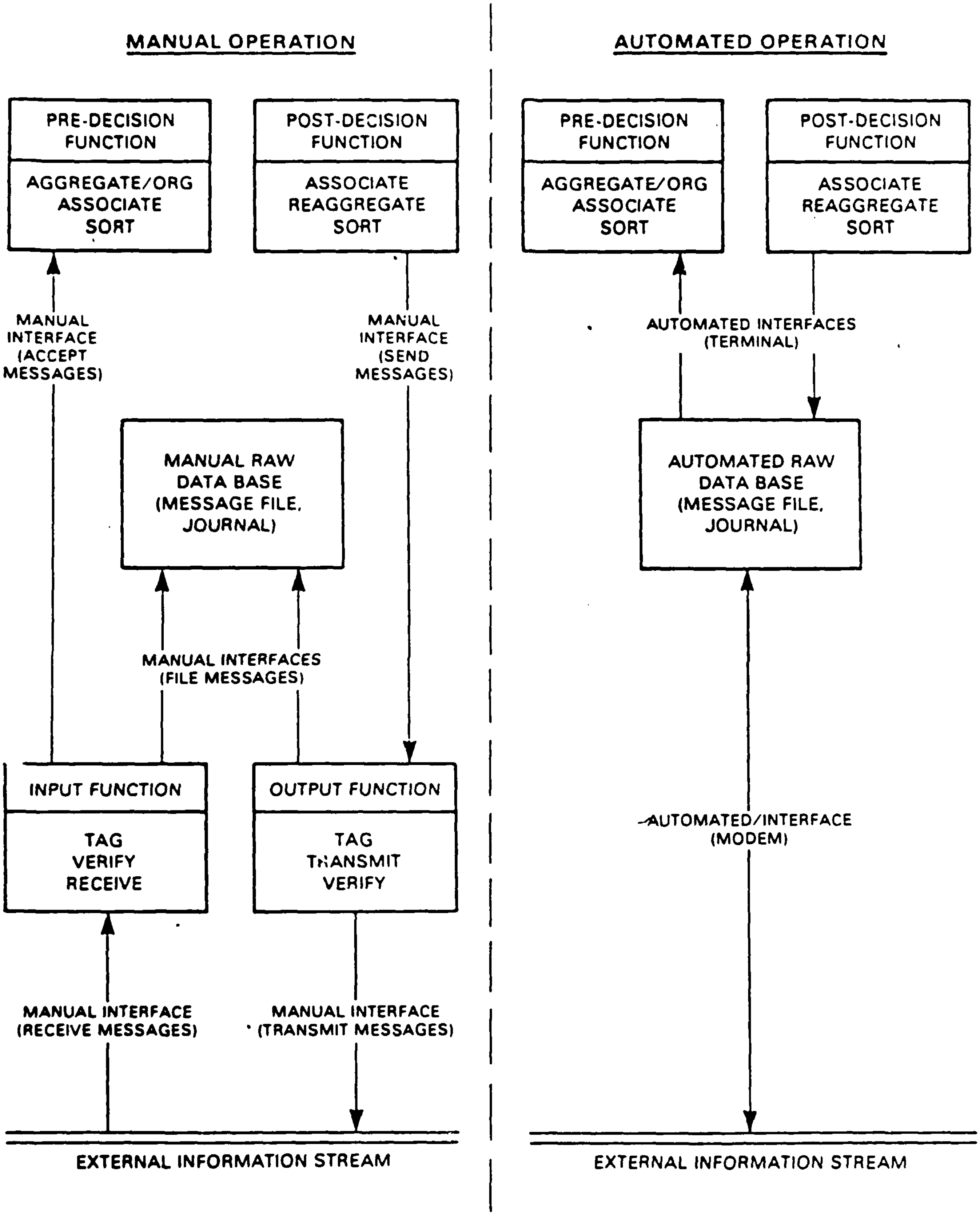


Figure 5-4. PARTIAL AUTOMATION — PRE-/POST-DECISION AND INPUT/OUTPUT FUNCTIONS

5.4. Total System Impact

How will ADP Application Affect SOP?

Do Redundant Data Bases Increase Workload?

What Effect Does Application Have on Workload Schedule?

How Does Application Affect Task Assignment?

How Does Application Affect Workspace Layout?

How Does Application Facilitate TOC Dispersion?

How Does Application Affect Required Communications?

The flow charts developed as described above are also very useful for assessing total system impact. To be complete they should, of course, include that part of the operation that remains manual as well as that which is proposed for automation. One needs now to develop a detailed SOP for system operation in the computer assisted mode in order to determine how automation affects the entire operation. In some cases the proposed automation could add to the manual workload, e.g., by requiring personnel to maintain duplicate data bases, or instead of smoothing out workload it could cause it to pile up at critical nodes. Careful study of the flow chart can disclose such potential pitfalls before they arise in actual practice. What you are doing here is assessing system costs that are outside the actual automated part of the revised system.

Whenever automation is used to process information continuously rather than a scheduled basis (e.g., a continuously updated appreciation of the situation from spot reports instead of periodic summary reports) there will be tendency to smooth out peaks in the loading.

This step will also help you identify changes in workload and needed changes in task assignment and workspace layout. It will also help avoid the fiasco of designing a system more difficult to operate than the manual mode.

Carrying out these steps will go a long way toward insuring a smooth transition to computer supported operations when you are ready to bring your application on line and will help avoid unpleasant surprises because of some factor that has been overlooked. It is recognized that you may not be able to identify all problems at this stage of the development process. However, major problems that could affect system operation and/or user acceptance should be identified at this time.

Returning to the Commander's briefing example, the remainder of this section examines some of the potential impacts of automating the briefing data base on the rest of the system.

5.4.1. Changes in Processing Load

In the manual, twice-daily briefing mode, the interface at A in Figure 5-1 (Commander-Briefing Data Base) consists of two discrete exchanges per day between the commander (commander group) and the staff briefers. Let's assume in our hypothetical staff that these occur at 0630 and 1830. Obviously, the staff must start building its briefing data base some time prior to the briefings. The result is the loading of the staff and of the communication channels which looks something like Figure 5-5. Sometime prior to each briefing the load peaks, usually at channel capacity. (Did you ever try to get a "flash" message into a corps TOC about 30 minutes before the evening briefing?)

Now let's consider what is likely to happen if we implement the commander's desire to automate the briefing data base and to keep it continuously current. The staff will now be updating the briefing data base (Interface B in Figure 5-1) as events occur and interpretations made. The commander will access these data and staff recommendations and enter his decisions through Interface A. Because the staff is continuously updating the briefing data base -- at the same time it is updating its own -- the processing load will be spread out over time with no peaks induced by scheduled briefing times. Both commo and staff activity will tend to follow much more closely the tempo of combat rather than an artificially imposed briefing schedule.

5.4.2. Data Base and Procedural Changes

A new digital data base must be constructed to meet the commander's briefing needs. Just what will be in this data base and how comprehensive it becomes depends largely on which of the commander's decision processes it is designed to support. Let's examine two extremes:

- Case 1

The commander can only request information that has already been interpreted, validated, evaluated, coordinated, projected, and extrapolated by the staff. He can evaluate only alternatives already generated by the staff and the computer provides no help in their evaluation, i.e., he has no capability to use the computer to generate answers to "what if" questions.

- Case 2

As the other extreme, the commander has the capability of conducting a dialogue with the computer. He can query to get the additional information needed for his personal interpretation, validation, and coordination just as he might during repartee at the briefing. He can ask the computer to project current trends and to make extrapolations as to likely future situations. He can enter new alternatives not considered by the staff and evaluate the probable outcome of various "what if" questions. In other words the computer support has become a true decision aid.

Now let's examine the impact of these two extremes on the operation of the TOC. For Case 1 the commander's briefing data base will be a compilation of relatively small subsets of the data contained in the various staff section

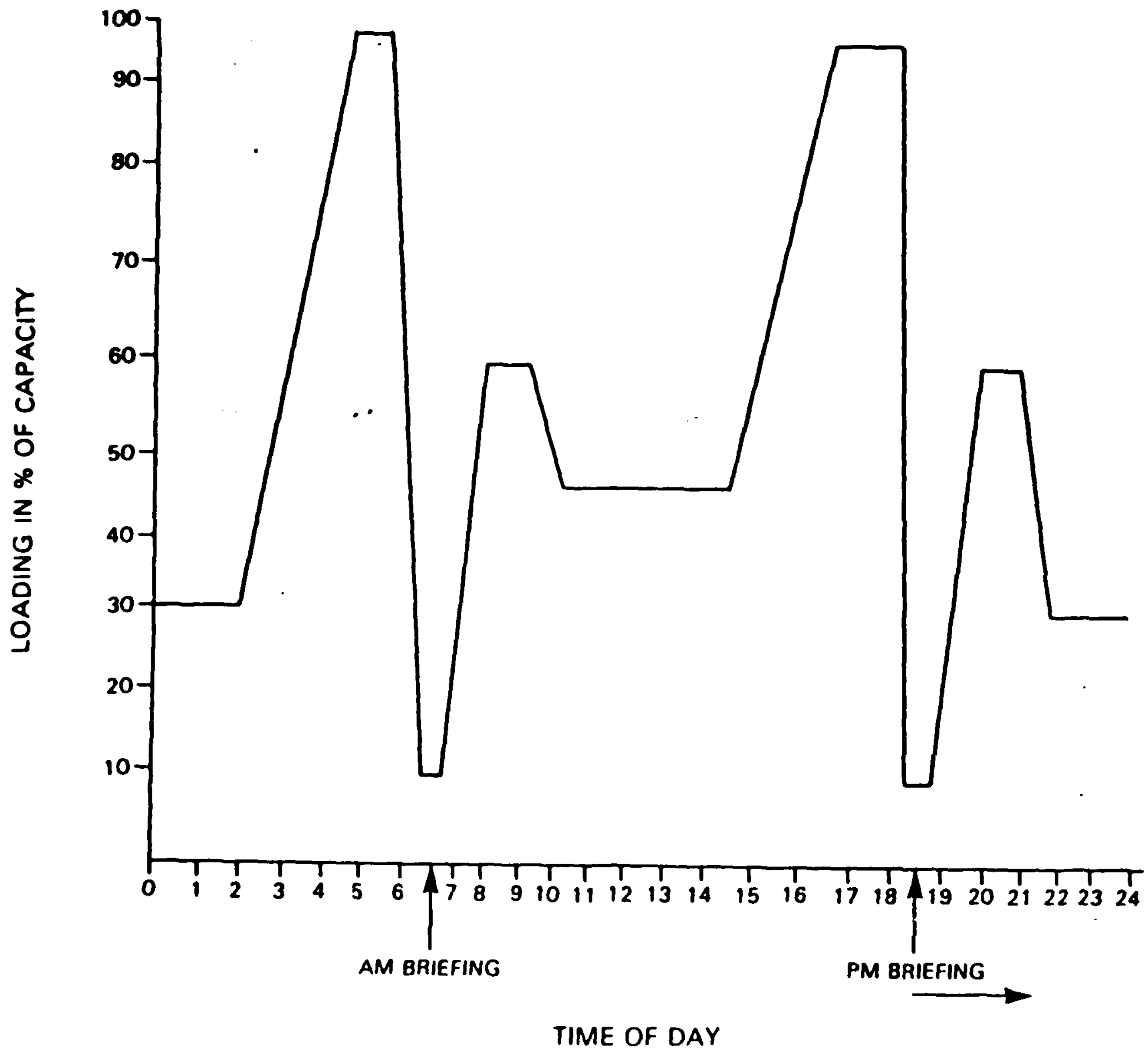


Figure 5-5. TOC & COMM ACTIVITY RELATIVE TO BRIEFING CYCLE

files. The only information that the staff sections will retrieve from the briefing data base will be any decisions entered by the commander and they might use it to refresh their memories as to "what did we last tell the old man"? There will be very little tendency for the staff sections to view the briefing data base as being in any way a substitute for their own section data base. The operation continues essentially as shown in Figure 5-1.

For Case 2 an entirely different situation will prevail. The briefing data base will tend to contain more and more information as the commander probes deeper into what the staff is telling him. As it grows the staff will discover how much faster and easier it is to retrieve the information they need for their own decision processes from the briefing data base rather than from their own files. Also, they can hardly be prevented (nor should they) from using the computer's capability to answer "what if" questions for their own staff decision making. The result of this will be that the staff will ignore its manually maintained, perceived data base and rely more and more on what is the, now automated, briefing data base. Figure 5-6 illustrates what has happened and shows the changes that have taken place in the original TOC operation depicted in Figure 5-1. The separate staff section data bases have completely disappeared. All sections and the commander now rely on a common perceived and automated data base. Interface B (STAFF-BRFG Data Base), which previously incorporated the transition from manual to digital data is now completely digital; interface C (STAFF-Section Data Base) has disappeared or it can be viewed as having been incorporated into Interface B. The transition of manual to digital has now shifted to Interface D (Pre-Post Decision-Automated Data Base). All of the staff section information processing above the input and output functions is being computer assisted. Surely, this represents a major change in the TOC operation and will require very careful review of SOPs.

5.4.3. Dispersed Operations

The discussion up to this point has been on a purely functional basis; nothing has been said about the physical location of either the information processes or the data bases. The third major potential impact of computer support is on the location of the various TOC activities. The ever broadening scope of the battlefield, both in terms of its size and the variety of sensors and weapons to be controlled and coordinated, coupled with the ever increasing pace of modern warfare have caused us to depend on larger and larger amounts of data. But we still have the same human limitations on the number of different factors that we can juggle simultaneously in making tactical decisions. We must depend increasingly on memory extenders (displays and files) and on information processing by others to aggregate, concentrate, and identify key factors to be considered in our decision making. If we do this manually we are physically tied to our information processing system. Staff sections are tied to their manual data bases. When they move the data base deteriorates rapidly and is not again usable until some time after they have gone back on-line and begun the slow process of updating it by hand. It takes significant time intervals to transfer current data from Alternate to Main and vice versa when we must depend on voice communication channels to make the transfer. Similarly, if the information collected and processed by the staff is presented to the commander by means of visual displays at briefings, all must be colocated -- usually in

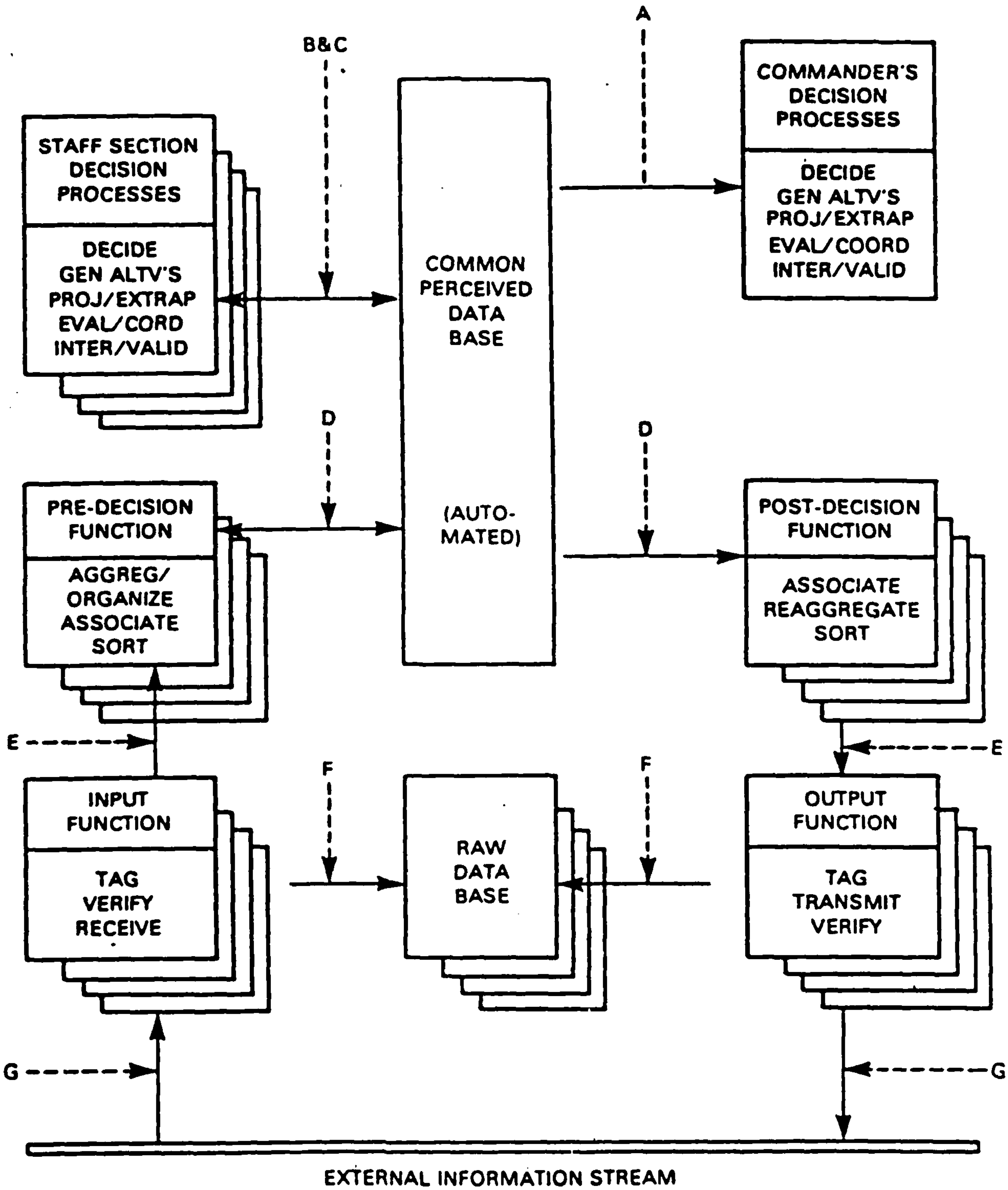


Figure 5-6. CASE 2 INFORMATION PROCESSING

the vicinity of the TOC. For much the same reasons, if the separate staff section data bases are to stay coordinated they must also be colocated -- again in the TOC.

Operating in the mode of Figure 5-6 is, however, quite a different story. Not only can the commander be located remotely from the common data base and still access the information he needs through automated interface "A", but the staff sections can also be separately located, communicating with the common data base through automated interfaces "B-C" and "D". Also the common data base, shown in the figure as a single functional entity, need not be all in one place. It, too, can be distributed among several locations reducing still further the vulnerability of the TOC. All this is subject to two caveats. First, the physically separated functional components and data bases must be interconnected with a network of digital communication which can also be made quite resistant to enemy interference through netting and automatic switching. Second, digital communication can replace a major fraction of current voice communication, but it can never replace it entirely. Some voice communication must be provided to fill the very human need for human interaction in times of stress.

CHAPTER 6: REQUIREMENT DEFINITION

It has been shown that C^2 operations may be considered as an information processing system composed of a number of components, in our case, functions and databases, which receive information either from another component or from the external world, process that information, and then transmit information to another component or to the external message stream. To facilitate communication between the field user, who is an expert in C^2 operations and best understands the automation concept, and the technicians, who must build the system, it is necessary for the user to precisely specify the information flow requirements for the automated system. This is accomplished by identifying each of the system components, describing the processing it must do, and specifying the nature and amount of information to be transferred between components.

If the application is relatively simple, the requirement definition may be done directly. In most cases, however, it is worthwhile to impose a measure of organization on the definition process. A useful technique for organizing the task is called the N^2 chart. It is a technique used by systems analysts in designing automated system architecture, but is equally useful to you in your capacity as the total (human/machine) system designer.

In a sense, the N^2 chart is the complement to the flow charts with which you are already familiar. Flow charts are built up of components (functions and data bases) and arrows connecting these to show the information flow between them. Hence a flow chart tends to emphasize functions and data bases. The N^2 chart, as you will see, emphasizes the interfaces (information transfers) between components.

You don't have to draw too many flow charts before you realize that the placement of the boxes representing the components is critical if you want to avoid confusion and crossovers when drawing the interface arrows. This is especially true if there are many such interconnections. If, however, we draw the function and data base boxes along the main diagonal of a large square, then every other small square off the diagonal represents a potential interface between a pair of components. By convention, the off-diagonal box represents information which flows <u>from</u> the component on the same row <u>to</u> the component in the same column. Figure 6-1 illustrates with an N^2 chart of 3 components. As can be seen, there are two small boxes for each possible pair of components, one box for each of the two possible directions of information flow. The box labeled number 1 in Figure 6-1, for example, represents information flow from component 1 to component 3, while the box labeled number 2 represents information transfer from component 2 to component 1.

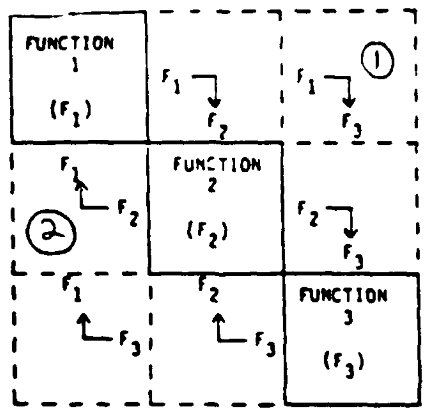


Figure 6-1. Sample N^2 Chart

This is easier to understand if we use a concrete example. Figure 6-2 is the N^2 chart corresponding to the flow chart of the operation section's processing contribution to the commander's briefing shown at Figure 5-1. The latter shows nine major components to be considered for the commander's briefing, so Figure 6-2 shows a 9 X 9 matrix with the function/data base boxes drawn as solid squares along the diagonal. All the other boxes in the matrix are outlined by dotted lines and represent all of the possible interfaces between the nine major components. There are 9 X 9 = 81 - 9 = 72 such potential interfaces. Granted, not all of these will actually exist, but the advantage of the N^2 chart is that it reminds you that they can and makes you justify every empty interface box where no interface occurs. Where an interface between components actually occurs a circle has been entered into the dotted square and the direction of information flow is indicated by an arrow. The same names have been entered in the diagonal component boxes as are used in Figure 5-1. The interface entries have been numbered and the letter used to identify the interfaces in Figure 5-1 has also been entered near the bottom of each circle in the interface boxes. Note that the N^2 chart has reminded us of four interfaces which are ignored in Figure 5-1 so that four circles (3, 4, 5, and 17) contain no letters. These represent the distinct possibility that pre-and post-processing may need to retrieve previously filed whole messages from the raw data base.

To continue the example, note that the flow shown in Figure 5-1 represents Case 1 (see Section 5.4.2.) in which the automated briefing data base (labeled *BRIEFING SOFTWARE* in Figure 5-1) provides the commander only selected predecision processed information and information subjected to the staff decision processes. It does not assist his own decision making by allowing him to repeat or expand staff decision processing by asking "what if" questions of the BRIEFING SOFTWARE. Only four man/machine interfaces are shown on the chart (11, 13, 14, and 16) and these have been marked with asterisks. These are functional designations; 11 and 13 would actually be multiple terminals for the several staff sections.

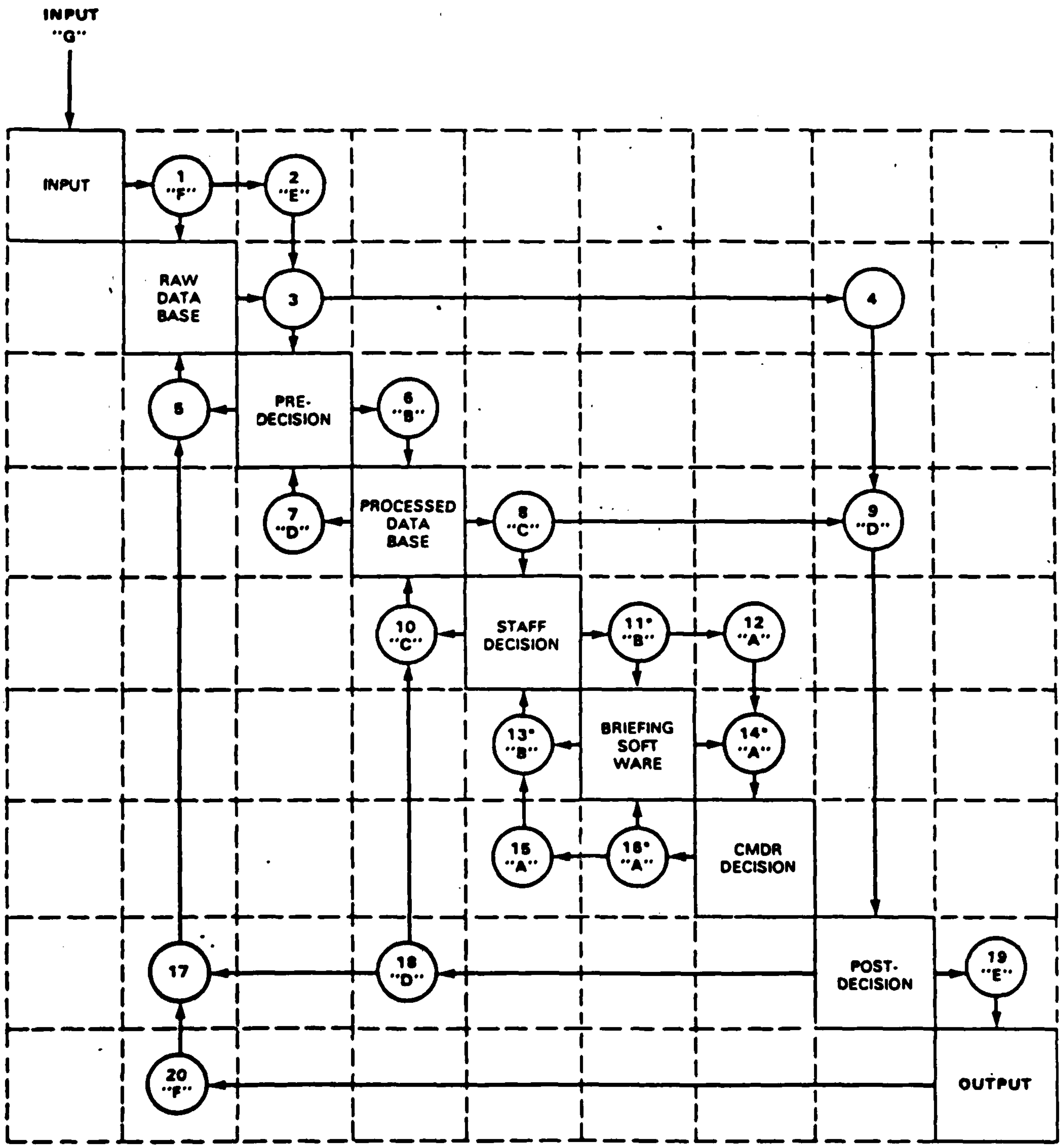


Figure 6-2. N² CHART OF THE COMMANDER'S BRIEFING

Table 6-1 can now be developed from the N^2 chart. It describes each of the major components and then describes the nature of every information exchange, i.e., the inputs to the TOC, the numbered interfaces, and the TOC outputs. Since all but four of the numbered interfaces represent manual data exchanges, these descriptions are in very general terms. In this connection the term "processed information" is shorthand for the information produced by the pre- and post-decision functions and "manipulated information" is shorthand for the output of the decision processes. The latter is distinguished by the fact that the decision processes contain information that was not contained in the incoming message stream (hypotheses, interpretations, extrapolations, etc.). It is when we come to the man-machine interface descriptions that requirements definition really begins. The power of the N^2 techniques springs from the fact that, once the inputs and outputs to the automated portion of the system have been adequately described, the technician can (with the operator-user's help) organize the needed data base and define the algorithms needed to convert input into output. For the present example this conversion is fairly simple, although outputs may well be in different format from inputs -- or even provide a capability to construct new formats from scratch.

The descriptions of the four automated interfaces shown in Table 6-1 are only the beginning. These must now be expanded to include every element of data to be transferable from staff to commander and return through the automated terminals and every format to be employed. If self-formatting is to be available, the range of such formatting must be agreed upon. You will note that Interfaces 15 and 12 provide the loop from commander to staff around the automated system. Since you cannot and do not desire to stop the commander from asking questions he cannot get answered through the automated terminal, it is this route that will be taken to get such information by voice communications. In deciding what information to transmit through the terminal, you are making a trade-off between these two means of communication, and you are adding to the workload involved in *STAFF DECISION* by requiring the staff to maintain two data bases. You will also note that this loop provides the back-up in case the automated system goes down -- it represents the original manual way of conducting the briefing.

Using this technique the user and technician working together can develop a statement that both understand and that avoids many of the gaps that all too frequently plague requirements drafted without dual participation.

Table 6-1.

Functional, Manual Data Base, and Interface Descriptions for the Commander's Briefing

Functional and Manual Data Base Descriptions

Input

- Receives, verifies, and tags incoming messages
- Enters messages in RAW DATA BASE
- Passes messages to PRE-DECISION

Raw Data Base (Manual)

- Stores messages in retrievable form
- Retrieves and passes selected messages to PRE-POST-DECISION

Pre-Decision Processing

- Sorts, associates, and aggregates/organizes information
- Files processed information in PROCESSED DATA BASE (manual)
- Queries RAW DATA BASE for selected messages

Processed Data Base (Manual)

- Stores processed information in retrievable form
- Provides information to PRE-POST-DECISION
- Stores manipulated information from STAFF DECISION
- Provides processed and manipulated information to STAFF DECISION

Staff Decision

- Retrieves processed and manipulated data from PROCESSED DATA BASE
- Files manipulated data in PROCESSED DATA BASE
- Files processed and manipulated data to BRIEFING SOFTWARE through terminal

Table 6-1 (Continued)

- Provides processed and manipulated data to COMMANDER DECISION by voice commo in response to queries

- Receives queries from COMMANDER DECISION by voice commo

Briefing Software

- Stores processed and manipulated data received from STAFF DECISION through terminal

- Responds to queries received from STAFF DECISION and COMMANDER DECISION through terminals

- Provides processed and manipulated information to STAFF DECISION and COMMANDER DECISION in response to queries through terminal

Commander Decision

- Receives processed and manipulated information from BRIEFING SOFTWARE through terminal

- Receives processed and manipulated information from STAFF DECISION by voice commo

- Queries BRIEFING SOFTWARE and sortes manipulated information there (including decisions) through terminal

- Queries STAFF DECISION and announces decisions by voice commo

Post-Decision

- Receives processed and manipulated data from PROCESSED DATA BASE

- Receives selected messages from RAW DATA BASE

- Queries PROCESSED DATA BASE for selected information

- Files processed information in PROCESSED DATA BASE

- Queries RAW DATA BASE for selected messages

- Composes outgoing messages and forwards to OUTPUT

Output

- Files outgoing messages in RAW DATA BASE

- Transmits, verifies, and tags outgoing messages

Table 6-1 (Continued)

<u>Inputs</u>

- Incoming communications traffic

<u>Interfaces</u>

1. Incoming messages
2. Incoming messages
3. Selected whole messages
4. Selected whole messages
5. Requests for selected messages
6. Processed information and requests for stored information
7. Requested information
8. Requested information
9. Requested information
10. Manipulated information
11. *Selected information in following categories:
    - Weather data and extrapolations
    - Terrain data and extrapolations
    - Friendly unit locations, status, capabilities
    - Enemy unit locations, status, capabilities
    - Mission
    - Organization for Combat
    - Order of Battle
    - Logistic Status
    - Admin Status
    - Courses of action considered

Table 6-1 (Continued)

- Enemy intentions/capabilities considered
- Staff recommendations
- Staff requests for any of above or for commander's entries

12. Staff responses to commander's requests for information not available from BRIEFING SOFTWARE

13. *Selected information in following categories:

    - Commander's planning guidance and decisions entered at Interface 16
    - Any categories entered at Interface 11

14. *Selected information in following categories:

    - Any categories entered at interface 11
    - Commander's planning guidance and decisions entered at Interface 16

15. - Requests to staff for information not available from BRIEFING SOFTWARE; planning guidance and decisions not enterable at Interface 16

16. *Selected information in following categories:

    - Requests for any categories entered at Interface 11
    - Requests for previously entered commander's planning guidance and decisions

17. Requests for selected messages

18. Processed information and requests for stored information

19. Outgoing messages

20. Outgoing messages

<u>Outputs</u>

- Outgoing communications traffic

CHAPTER 7: CONDUCTING THE DEMONSTRATION AND TRIALS

The initial demonstration and trials is the most important milestone in the entire effort. If the commander and senior staff do not have the impression that computer support can improve their C^2 operation, the entire effort is clearly in trouble. Here are a few rules that will help avoid that outcome.

1. Involve the users during the software development phase. During software development, the user is needed to provide advice and guidance to the technician, to confer on what the user will find acceptable, to evaluate the proposed interfaces -- especially, displays, and to be available for "hands-on" training especially for the operators of the equipment. Don't forget that in the example cited above the principal operators are the commander and the senior staff. These operators should be exposed to the automated support almost as soon as the first displays can be brought up on the equipment. Do not wait until the system is ready to be operated in the field. Initial exposure should be in garrison and should be continuing throughout the development phase. In addition to giving the future operators experience and confidence in computer support, thus minimizing "computer anxiety" (the fear of bringing the whole system down or looking foolish before others because of a stupid mistake) this early user involvement will pay tremendous dividends in fielding a more usable system and insuring much earlier user acceptance.

2. A thorough and complete plan for the demonstration and trials must have been completed while the proposed computer support was being developed. Planning for the initial trials is somewhat similar to planning for an FTX or a map exercise. The scale of the trials will be determined by the nature of the applications being tested. Trying out a movement order generator does not require a full-blown CPX; trial of an automated briefing system probably does -- at least a reduced scale exercise on the grounds of home station. There must be means for providing an information load to the system. How elaborate this is again depends on the application being tested. This could range from a simple scenario to a full-blown Master Incident List to a battle simulation.

You must begin with a set of test objectives tied directly to the changes in C^2 performance sought by means of the automation support being tested. These will indicate the nature and extent of the combat environment to be simulated in order to load the TOC if the application is tactical, and to provide the information needed to generate the products to be tested. In addition to fielding the TOC, the plan must also provide for the umpires or controllers necessary for simulating the battle events and for the data collectors necessary to gather the quantitative measures of goal achievement.

3. Remember that you are conducting an experiment; good experimentation requires a controlled environment. This means you must minimize the effects of all variables except those you are trying to measure. This second rule is probably the one most difficult to apply. Whenever any tactical exercise is proposed there is always the tendency to add as many training objectives as possible. This must be avoided for the initial trials and is another reason for the personal involvement of the commander and senior staff. The activity most closely tied to C^2 is, of course, communication, but discovering the

training deficiencies of the signal battalion or brigade is not the objective of the initial trials of the computer support application. The initial trial should take place in garrison or with hard wired, reduced distance communication so that the disturbing effects of everything but the computer support of operations is held to a minimum. Later experimentation with alternative communication nets is certainly warranted to discover optimal C^2 configurations, but the initial trials of a new automation application must eliminate as far as possible the uncontrolled variables of a full-blown communication system. The same principle applies to any other possible source of impact on the C^2 system. The objective of the initial trials must be to measure the change in performance resulting from the computer support to C^2 operations — don't dilute it by trying to determine the effect of other changes. Reducing the scale of the exercise to the minimum needed to reach that objective will reduce the expenditure of limited training funds and, thus, the pressure to add training objectives.

4. A detailed SOP for use with the computer support must have been developed; the initial trials are a test of that SOP as well as of the computer support. You will already have initiated compliance with the third rule when you analyzed the total system impact of automation, especially the initial increment, during the concept development. Looking at the changes in SOP inevitably associated with your initial application was part of that exercise. This needs to be extended and modified as the development proceeds to take into account the inevitable changes in requirements and new insights provided as the user gets involved during the development phase. The important point is that everyone involved must have a clear idea of what the application is to be used for, who operates the equipment, and how it is to be employed. Well trained equipment operators who have already had extensive experience with the equipment in garrison are part and parcel of this rule.

5. The entire staff (not just the operators and data collectors) must have been oriented in advance as to the test objectives, the goals of the effort, and the measures of accomplishment. The entire staff — that is, everyone involved in the trials — must be oriented on what the demonstration and trials are all about. Not only will this improve the trial, but it is amazing what insights toward improvement of the whole operation can be provided by knowledgeable persons who have been adequately briefed even though not immediately associated with the computer support. This rule also reinforces the importance of the operating principle stated previously, namely, that automation must be phased in gradually in steps sufficiently small that they can be absorbed by the staff without completely changing their method of operation in one fell swoop. Nothing can be more devastating to acceptance of computer support than trying to impose too much change in the first step.

A major purpose of this manual is to assist you in gaining initial and maintaining continuing acceptance of the new modes of operation that inevitably will accompany the introduction and assimilation of automation into your unit C^2 operations.

The following set of principles summarizes the experience of others in making this transition successfully:

• You must inspire confidence in the ability of automated hardware and software to assist in tactical operations. Don't bite off more than you can chew initially; it is far better to have people panting for the next application than to swamp them with more than they can absorb.

• You must avoid even the appearance of adding to the workload; "If it doesn't make my job easier, it's no good."

• You must overcome "computer anxiety" by exposing the ultimate operator to the equipment as soon as possible. He must be thoroughly familiar with it prior to the initial demonstration and trials.

• While you must not let communication difficulties unduly affect your initial demonstration and trials, you must be ever aware that the ultimate constraints imposed by your communication net must be considered in your total command and control system design.

Familiarity with, and confidence in a system seem to be the primary factors in user acceptance — that is, assuming the system's utility in aiding user functions has been perceived. If the system is perceived to create additional workload, user resistance will be difficult to overcome.

When the users become aware of how the system will assist them in the performance of their jobs, the next hurdle seems to be overcoming "computer anxiety." Developing a familiarity with the computer to overcome these fears is the first step in training. Training cannot be effective until the user is at ease and comfortable with the machine. In many cases some portion of the application already developed will be applicable to peacetime operations in garrison. This use should be encouraged and will greatly aid in gaining user acceptance.

Another major factor in user acceptance is confidence in the system. This is related to perception of utility. When the users are not confident in the system they take precautions against its failure, i.e., maintain the manual system also. This creates additional work and the computer, because of its perceived lack of reliability, is blamed for the increase. To some extent increased familiarity will lead to increased confidence; however, the system must, in fact, be reliable. Periodic failures, loss of data, and nonavailability when needed will be amplified in the mind of the user and must be minimized to develop confidence that the system is, and will be a worthwhile tool for the user.

The user's exposure to the computer system must be continuous in order to develop and maintain familiarity with its use. System applications must be developed for use in garrison to facilitate this. A system which is used only in field operations creates a training/relearning problem prior to and in the early stages of every exercise. "User friendly" is a catchy phrase which has different meanings for different people and always requires tremendous overhead within the computer system. We are a long way from having computer systems which can carry on human-like conversations and, therefore, are forced to learn to talk to the computer in ways it can understand. If we expect the computer to be of use in a "come as you are" war, users must be totally familiar with and comfortable with the system. There will be no time to get up to speed in its use.

Communications capability is rapidly becoming the limiting factor in the transfer or exchange of data in organizations using automated data systems. In order to realize the full benefit of computers, data must be transferred between locations rapidly. Decision support in tactical command and control can require large data transfers, especially when such transfers are not limited to the dynamic data elements and include large blocks or relatively stationary data which could have been stored locally. It has become evident in some of the initiatives that hand carrying large files on magnetic disk could relieve system congestion and even save time in the transfer. Possibilities for communication upgrades must be examined and fielded to take full advantage of the automated data capabilities.

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